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POWER

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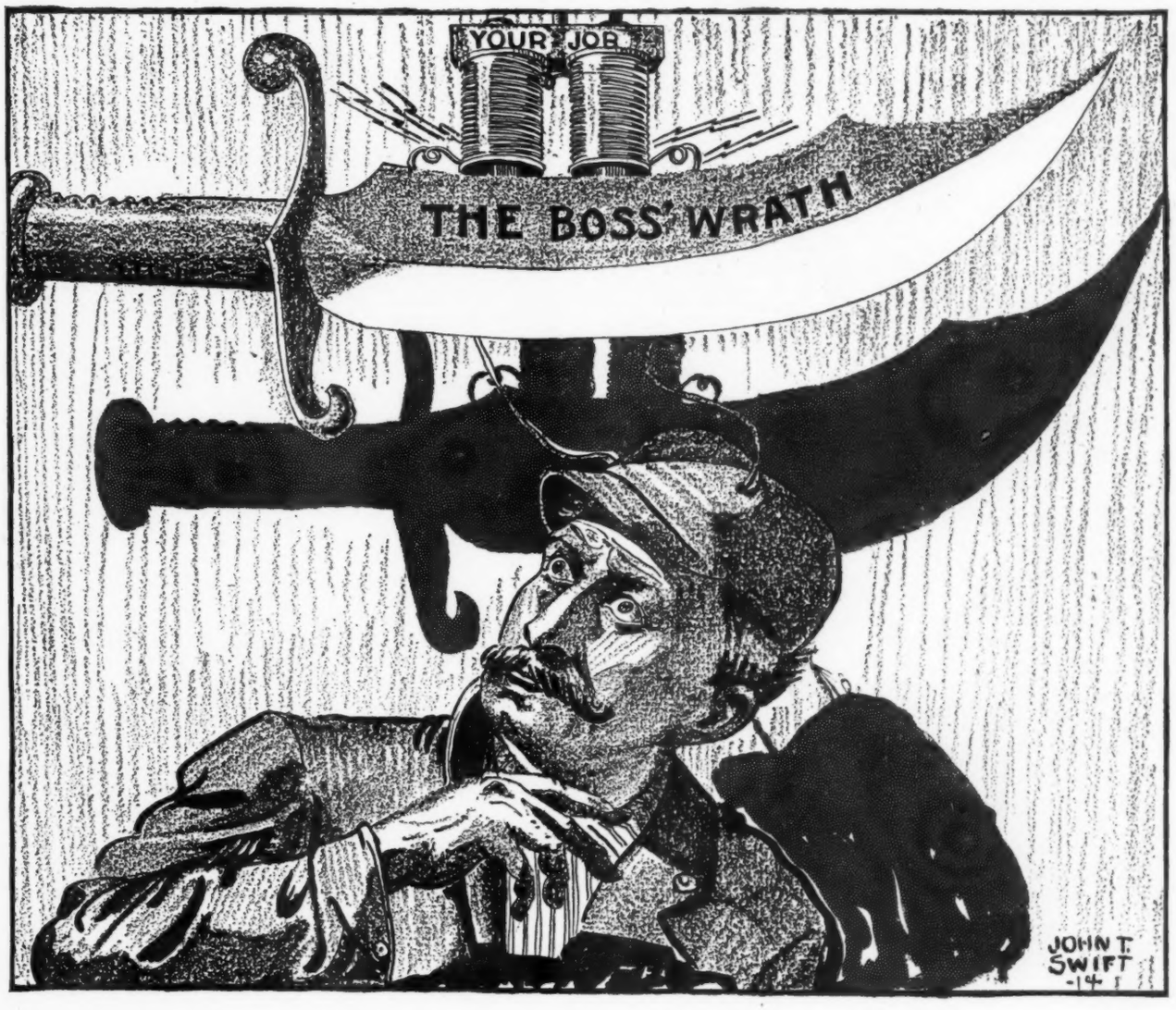

The Sword of Damocles

CREEPY, EH? No need to be if you KNOW your work. Merely a matter of carrying mental voltage enough to hold that meat-ax in place. Even tho' your job is a horseshoe magnet, yet—LUCK won't do. Soon another nick will appear on that handle, recording your demise if you have nothing on your mind but your hair. GET BUSY. Put some "JUICE" under your hat. And begin today. NOW!

Heating and Ventilating System of American Cigar Co.'s Plant

By W. L. Durand

SYNOPSIS—Modern demands for comfort and convenience in the heating and ventilation of factory buildings have far outrun the relatively simple requirements of former years. An interesting example of modern tendencies is found in the equipment of a new factory erected for the American Cigar Co.

The new building of the American Cigar Co., Garfield, N. J., covers an area of 15,000 sq.ft.; it is five stories high and has a floor area of 50,000 sq.ft. It is used exclusively for the manufacture of cigars and about 1000 persons are employed.

The power plant, Fig. 1, is located in the basement, with natural light for the engine room and a convenient arrangement for handling the coal and ashes.

The boiler room is equipped with two 75-hp. horizontal return-tubular boilers arranged in a battery. While 125 lb. pressure is carried, the boilers are built to withstand 150 lb. The boiler furnaces are equipped with bridge-wall dampers and ducts leading to the rear of the setting, so that if it is desired later to increase the output by the addition of forced draft, no changes to the setting will be necessary.

The water for the boilers is taken from a driven well in the pump room. Two 4½x2¾x4-in. duplex, outside-packed plunger pumps are so connected that either one can be used to pump water from the well to the feed-water heater, to the boilers direct, or from the feed-water heater to the boilers. The steam piping is arranged to control the pumps by throttle valves when pumping from the feed-water heater to the boilers, or by means of a float in the feed-water heater when pumping from the well to the heater. This arrangement permits of one pump being used to handle makeup water to the feed-water heater under automatic control, the other to be used as a boiler-feed pump; in case of a breakdown to either pump, water can be fed direct to the boilers by the other.

A hydraulic damper regulator is used in connection with a balanced damper in the main smoke flue. If forced draft is installed this will also be used to operate a balanced valve in the steam connection to the forced-draft fan, permitting automatic control.

Bituminous coal is burned in the boilers. It is stored in a pocket adjacent to the boiler room, the coal being supplied from a driveway overhead. The ashes are removed by an overhead trolley which discharges directly to the driveway.

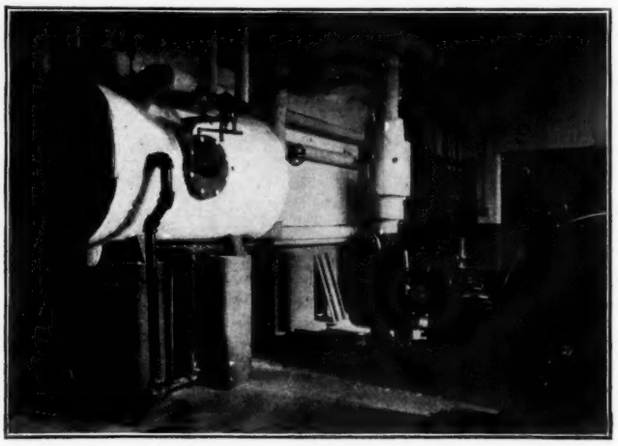

Fig. 1. Partial View of the Engine Room

The engine room is equipped with a 10x12-in. high-speed engine directly connected to a three-wire, direct-current 110-volt generator. It was the first intention to use a four-valve engine, but after going into the situation it was found that engine economy was of value only during the summer months when the load was the lightest, and that the saving would not be sufficient to warrant the increased cost of both engine and generator. The increased cost of the generator would be almost as much as that of the engine, due to the lower speed of this type of engine. No breakdown service or extra unit was installed,

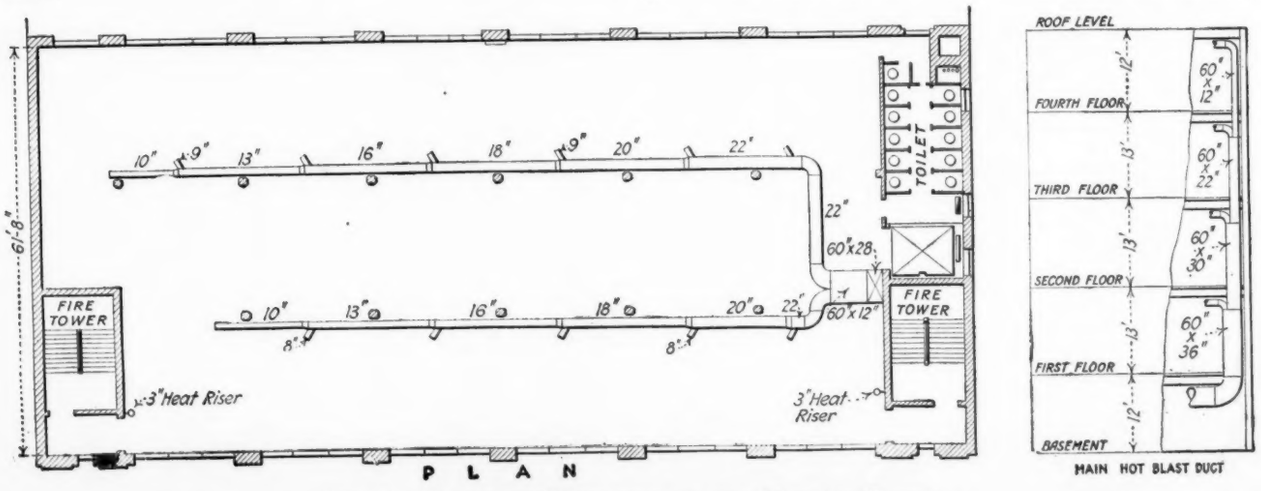

Fig. 2. Plan and Elevation of the Hot-Air Ducts

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since the character of this factory did not seem to warrant the extra expenditure.

Exhaust steam from the engine and pumps passes to a feed-water heater and is then used for heating hot-blast coils, with provision for using live steam from the boilers through a double set of reducing valves.

The building is heated by means of a hot-blast system supplemented by a few coils and radiators. The air in entering passes first through a tempering coil, an air washer, and a reheater to the intake of the supply fan. From the supply fan it is distributed by a main riser with two branch ducts on each floor. Fig. 2 is a plan and elevation of the hot-air ducts. Fig. 3 is a plan view of the engine, boiler and air-washing rooms.

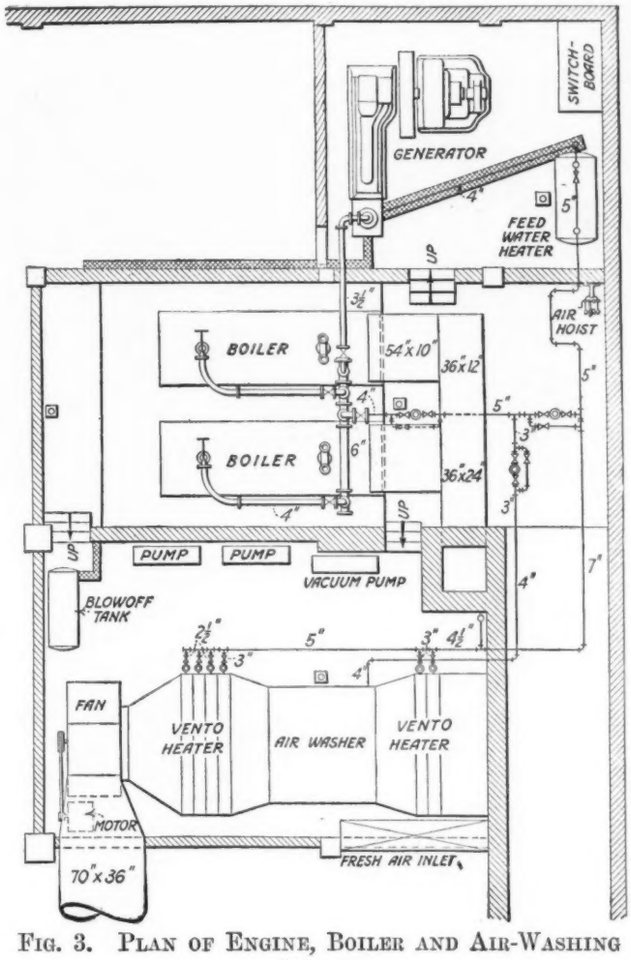


FIG. 3. PLAN OF ENGINE, BOILER AND AIR-WASHING ROOMS

The tempering coil consists of two groups of 60-in. cast-iron heaters set on 5-in. centers. Each group contains 20 sections, making a total of 640 sq.ft. The coils raise the air to a certain necessary minimum temperature, as later described, before passing to the air washer.

The air washer consists of a metal spray chamber through which the air is drawn. Under the chamber is a tank which is kept filled with water. A centrifugal pump driven by a directly connected motor draws water from this tank and forces it through the spray nozzles. The nozzles, of which there are approximately seventy, are uniformly distributed over the cross-section of the washer, so that this chamber is filled with a fine mist so dense that it is impossible for the air to carry any dirt through it without the latter becoming wet and heavy. At the end through which the air leaves the spray chamber is placed a set of eliminator plates, which extract all the water and dirt. These plates are kept flooded, so that dirt is washed into the settling tank.

This apparatus is provided with an arrangement for automatically controlling the humidity. The spray water is heated when the humidity is too low, in order to increase the evaporation; this heating is controlled by a

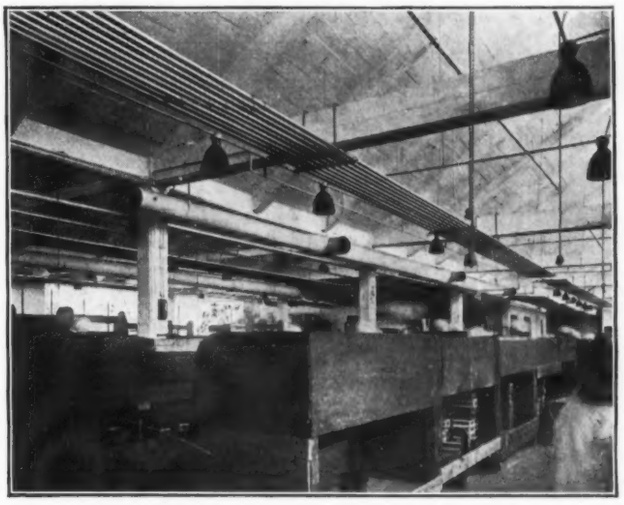


FIG. 4. SHOWING AIR DUCTS AND STEAM COILS ON THE TOP FLOOR

thermostat placed in the air duct leading away from the apparatus. While one of the functions of an air washer is to remove dust and floating solid matter from the air before entering the rooms to be heated, the principal reason for installing one in this factory is for humidifying the air, and in order to give the best possible conditions for the manufacture of cigars it was decided to maintain a humidity of at least 65 per cent. at all times.

For the proper operation of this apparatus the temperature of the entering air should fulfill two conditions—it must be not less than 32 deg. F. to avoid danger of freezing the water in the washer, and it should have such a temperature that when saturated, as it is when leaving the washer, it will carry such a moisture content as will give it, at the desired room temperature, a relative humidity of 65 per cent.

The heating stacks consist of four groups of 60-in. cast-iron heaters. Each group contains 22 sections, making a total of 1408 sq.ft.

The fan is a 54-in. diameter multivane, and it has a capacity of 25,000 cu.ft. of air per minute against a pressure of 1 in. of water. It is driven by a directly connected 10-hp. engine. The reason for using an engine in preference to a motor is that in case of a breakdown to the engine generator set the building could still be kept warm and work would not have to be entirely suspended.

The factor determining the amount of air circulated was the number of occupants. This being fixed, the heat losses were computed, and the required temperature of air from the reheater for extreme conditions was found to be 120 deg. F., which temperature is given by the arrangement outlined above.

On the first floor, which has an extended wing, and on the top floor, Fig. 4, steam coils are installed to offset the heat losses through the roof. This is necessary to pre-

vent an excess of air on these floors, which would occur if these losses were taken care of by the hot-blast system. The arrangement of the air ducts and outlets on the other floors is shown in Fig. 5.

The entire heating apparatus is governed by an automatic temperature-controlling system. One thermostat is located between the primary heater and the air washer, controlling supply valves on both sections. The valves are fitted with differential springs, the outer section being the last to close, so as to maintain temperatures from 45

FIG. 5. ARRANGEMENT OF AIR DUCTS AND OUTLETS ON THE CENTER FLOORS

to 55 deg. F., as desired. One thermostat is located in the air washer, as previously described. One thermostat of the two-relay pattern, adjustable from 65 to 125 deg., is located in the duct beyond the reheater and controls the four valves on the steam supply to the reheater. Two thermostats on the first floor, and three on the top floor control the ceiling coils.

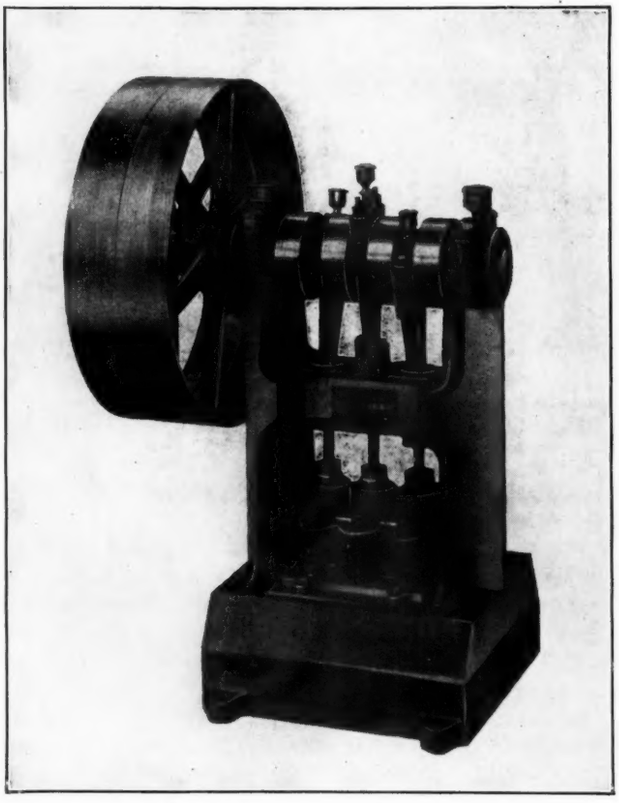
A vacuum system is used in connection with all coils, radiators and stacks. The condensation is carried to a 6x7x8-in. vacuum pump with suction strainer and vacuum governor. The discharge on the pump is carried to a standpipe with a vent to the atmosphere, instead of the customary air-separating tank. From there it flows to the feed-water heater. With a heating system of this character it is possible to carry a vacuum of 1 to 2 in. of mercury on the steam side of the system and 7 to 8 in. on the return side.

The covering is 85 per cent. magnesia for all steam pipes in the basement, being 2 in. thick on the high-pressure and 1 in. on the low-pressure. The exhaust pipe, which is in a chase, is covered to the fourth floor, where the last connection is taken off. No vacuum return pipes are covered.

As this is one of the first buildings in this country used exclusively for the manufacture of cigars to install an air washer and is in the nature of an experiment, the comparison of the results obtained at this factory with similar factories owned by the same company, but heated by steam with no ventilation and humidity control, will be watched with interest.

Single-Acting Hydraulic Pump

This pump fills the requirements where a uniform flow of a small quantity of water under high pressure is required. When motor-driven it may be mounted on a truck and used as a portable outfit. It is provided with a knockout attachment that automatically cuts off the deliv-



SINGLE-ACTING TRIPLEX HYDRAULIC PUMP

ery of water, but holds the pressure when the predetermined maximum is reached. A slight drop in the pressure automatically starts the flow, which continues until the maximum is again reached. The base of the pump forms a reservoir for the liquid used in the operation.

PRINCIPAL EQUIPMENT OF THE AMERICAN CIGAR CO.'S NEW PLANT, GARFIELD, N. J.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Return-tubular	75-hp	Steam generators	Hand-fired, 125 lb. steam, natural draft	E. Keeler Co.
1	Engine	Ide	10x12-in	Main units	125 lb. steam-saturated	A. L. Ide & Sons
2	Pumps	Duplex	6x4x6-in	Boiler feed and makeup water	Automatic and hand regulated	Henry R. Worthington
1	Generator	Direct-current	50-kw	Main unit	110-220-volt, 3-wire system	Westinghouse Elec. & Mfg. Co.
1	Heater	Combination	150-hp	Heating feed water	Using exhaust steam	Linton Machine Co.
1	Fan	Sirocco	54-in., 25,000 cu.ft. per min.	Hot-blast system	230 r.p.m.	American Blower Co.
1	Engine	Vertical, high-speed	10-hp., 6x6-in. cyl.	Driving fan	230 r.p.m., 125 lb. steam	American Blower Co.
1	Air washer	Wet	70-nozzle	Washing ventilating air		American Blower Co.
1	Pump	Centrifugal	2-in.	Water for spray nozzles	1200 r.p.m. capacity, 120 gal. per hr.	American Well Works
1	Motor	Direct-current	5-hp	Driving cen. pump	1200 r.p.m., 220-volt	Westinghouse Elec. & Mfg. Co.
2	Heater groups	Vento, 60-in.	20 sections each, total 640x sq.ft.	Tempering air	0 to 50 deg.	American Radiator Co.
4	Heater groups	Vento, 60-in.	20 sections each, total 1408 sq.ft.	Heating air	50 to 120 deg.	American Radiator Co.
1	Control system	Thermostat		Heating system	Automatic	Power Regulator Co.
1	Vacuum system	Donnelly		Heating system	Automatic	Jenkins Brothers
1	Pump	Simplex	6x7x8-in.	Handles condensate	10-in. vacuum	International Steam Pump Co.

The pump is built for either gear, chain or belt drive. The design is such that any one of twelve different-sized plungers may be furnished, ranging from $\frac{3}{16}$- to 1-in. diameter, advancing by increments of $\frac{1}{16}$ in. They are capable of exerting a maximum pressure ranging from 750 to 8000 lb. per sq.in. The three plungers are of the same diameter and work to the same maximum pressure. The stroke is $2\frac{3}{4}$ in. Each has a speed of 35 ft. per min. at 150 strokes, which is the rated speed, and gives the pump a total capacity of 0.41 to 4.20 gal. per min., depending upon the diameter of the plungers. The suction and discharge valves are located in the pump cylinder.

The plungers are bronze, except on the $\frac{5}{16}$- and $\frac{3}{8}$-in. sizes, where steel is used to withstand the high pressure. The cylinders are cast *en bloc*. With the $\frac{5}{16}$-in. and the $\frac{3}{8}$-in. plungers cylinders of forged steel are used, and for the pumps having larger plunger diameters a special bronze is used. The height over all is 35 in. and the floor space required is 16x18 in. The weight is 500 lb.

This pump is manufactured by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio.

Piping and Supports in Municipal Plant

By A. D. Williams

SYNOPSIS—Some unusual features found in the steam piping at the East Fifty-third St. Station, Cleveland Municipal Electric-Light Plant.

The East Fifty-third St. Station at Cleveland is designed to operate at 225 to 250 lb. steam pressure with a superheat of 125 to 150 deg. F., steam temperatures of 525 to 600 deg. F. being obtained when the plant was tested. The boilers are of the Stirling "Delray" type with two superheaters each, from which the steam is taken off through nonreturn valves and 8-in. steam lines to a main header divided in three sections, from each of which one of the main units is supplied.

One of the features of the steam piping is the use of flanges welded to the pipes and welded steel nozzles on the header and manifold, pipe bends being used for all changes of direction; the only castings used in connection with the live steam piping are the valves. Like most modern plants, this station is designed upon the unit system and may be operated as though it consisted of three separate plants. In one way, however, it departs from the unit design, namely, in the use of a large main steam header instead of cross-connection loops between units. This header is placed in the basement, near the wall between the boiler and turbine rooms, and is the lowest point in the steam line. It is divided in two sections by an expansion loop (Figs. 1 and 4), each section ending with a manifold tee having four side outlets from which 6-in. inverted "U" pipe bends are taken off and connect with the other section. The combined area of the bends is slightly less than the area of the header. The two manifold tees are dead-ended next to the wall by forged-steel bumped heads welded on, the opposite end being closed by a blind flange. Each section of the header is anchored midway between its ends and is supported elsewhere by rollers, as shown in Figs. 2 and 5. At each anchor point the pipe rests in a heavy cast saddle, to which it is secured by clamping rings, and bands welded to the pipe at these points assist in preventing any slipping of the rings. Each section of the header contains one Venturi Hopkinson-Ferranti stop valve by means of which the plant can be separated into three operating units.

This header, being the lowest point of the steam piping, is provided with drain outlets piped to a trap set in a pit below the floor; this provision is necessary, even with superheated steam. A stop valve is placed in each of the turbine steam leads next to the header, with the valve stem set at a 30-deg. angle (Fig. 2). Each boiler lead

Fig. 1. Expansion Bend in Main Steam Header

is also provided with a stop valve just beyond the bend to the header, and the leads to the far side of the boiler room are supported at the boiler-floor level by floor-plates and supporting rings designed to permit free expansion in the long lead below the floor. These sliding floor-plates are shown in Fig. 6.

Fig. 7 shows the construction of two supports for the feed-water pipes—one a steel bracket anchor built up of angles and plates, the other a cast-iron saddle anchor with

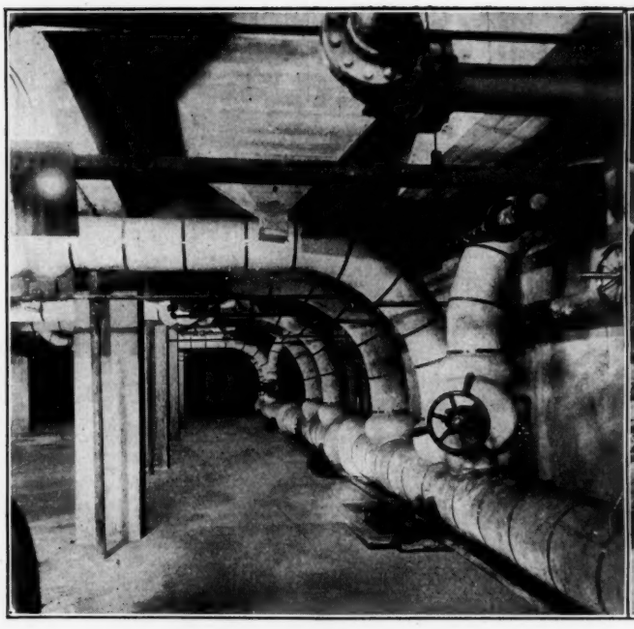


FIG. 2. SOUTH END OF HEADER, SHOWING SUPPORTS AND ANCHOR

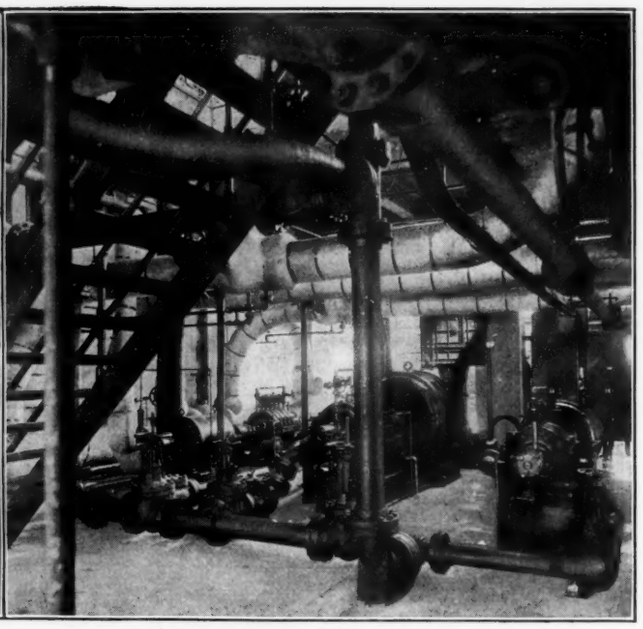


FIG. 3. PIPING AT BOILER-FEED PUMPS, LOOKING NORTH, AND NORTH END OF HEADER

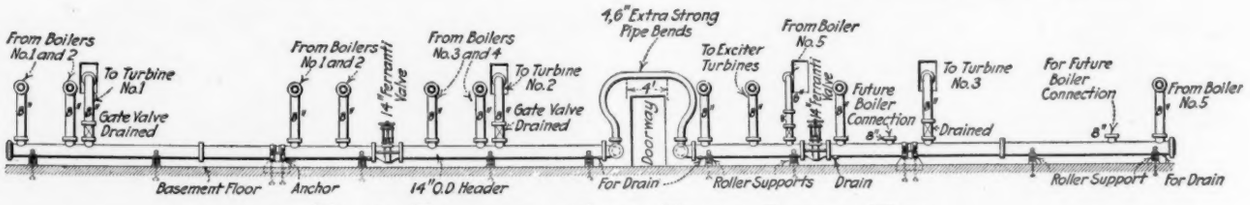
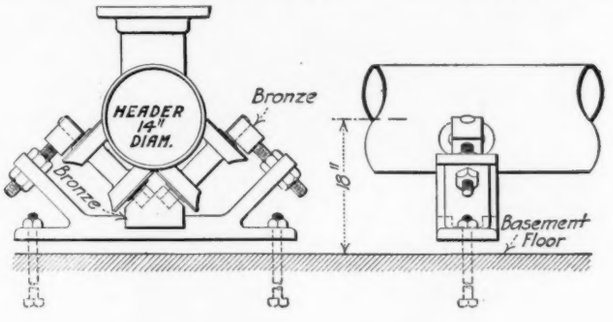


FIG. 4. ELEVATION OF STEAM HEADER, LOOKING WEST

a steel clamping plate to hold the pipe. Both of these supports are secured to the masonry by expansion bolts.

Figs. 3 and 8 show the arrangement of the boiler-feed pumps and the piping at this point. Three five-stage centrifugal pumps are installed, all being designed to operate at 1750 r.p.m. against a pressure head of 720 ft. One pump, for emergency service, is driven by a 125-hp. steam turbine and has a capacity of 350 gal. per min. The center pump has a capacity of 750 gal. per min. and is driven by a 250-hp., 440-volt, three-phase induction motor. The third pump is driven by a 125-hp. induction motor and has a capacity of 350 gal. per min. The feed-water supply is drawn from the hotwell into which the condensate from the surface condensers is discharged, a sufficient head being maintained to cause the water to flow to the V-notch meter through a 12-in. supply line. All of the pumps draw on a suction header to which the water from the meter flows through an 8-in. line, and an 8-in. bypass is provided around the meter. From the pumps the water enters a pressure header from which lines run to both economizers. Two bypass risers are provided which connect to the boiler-feed loop. The pressure end of the boiler-feed system is arranged so that there are two possible routes for either hot or cold feed water between the pumps and the boilers.

The use of electrically driven auxiliaries for the condensers, induced draft and forced draft, and for the stoker drive and boiler feed, eliminates a large amount of small steam piping and exhaust lines. All of the piping under high pressure is extra strong lap-welded medium-steel with cast-steel fittings. The low-pressure piping is of standard-weight wrought iron, cast iron or, as in the case of the free exhaust line, spiral riveted pipe. Each turbine is connected to the free exhaust line by a 24-in.



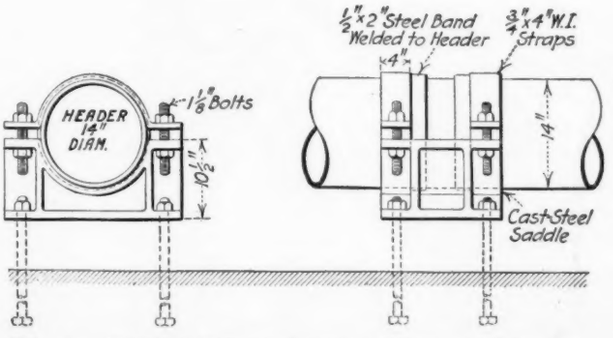


FIG. 5. ROLLER SUPPORT AND ANCHOR BLOCKS FOR MAIN STEAM HEADER

free exhaust valve on the condenser. A 24-in. header is located in the turbine-room basement, just below the floor, and a riser at the center of this header passes up through the floor, then diagonally through the wall into the boiler room and ends just above the roof. This riser,

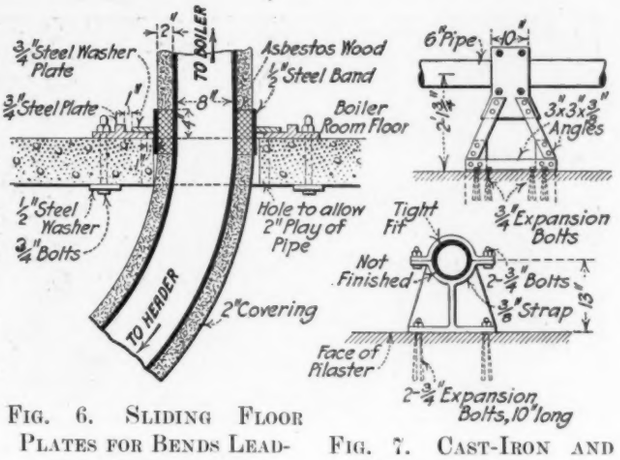


FIG. 6. SLIDING FLOOR PLATES FOR BENDS LEADING TO BOILERS NOS. 1, 3 AND 5

FIG. 7. CAST-IRON AND STEEL ANCHORS FOR 6-IN. PIPES

which may be called upon to carry the exhaust from three 5000-kw. turbines, is the same size as the header and the free exhaust valves.

The nominal overload steam requirements of the turbines is about 70,000 lb. per hour. This is brought to the turbine through an 8-in. pipe, the velocity of flow being about 117 ft. per second. In the exhaust line this amount

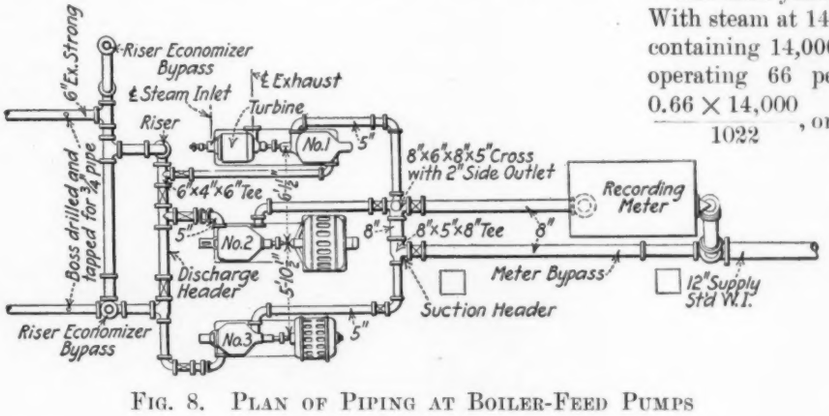


FIG. 8. PLAN OF PIPING AT BOILER-FEED PUMPS

of steam could be carried with a velocity of about 140 ft. per second, at 17 lb. absolute pressure. The reduction in cost of the pipe and covering for small sizes is considerable, so that for economic reasons the pipe should be the smallest size that will pass the steam with the maximum permissible friction and radiation losses.

TYPICAL CONDENSER DATA AND PERFORMANCE

Horse-power	Steam, Lb. per Hr.	Cooling Surface, Sq.Ft.	Condensation Rate in Lb. per Sq.Ft.	Actual Vacuum 30-in. Bar	Circulating Water, Deg. F.	Hot-well Temp., Deg. F.
5,800	87,000	3,282	26.5	26.8	44	110
12,000	180,000	8,000	2.5	27.7	72	104
12,000	180,000	8,636	20.8	28.95	49	69
12,000	174,000	8,440	20.6	27.2	53	98
22,000	340,000	16,820	20.25	28.8	54	78
27,000	418,500	21,600	19.375	28.85	57	76
17,000	240,000	9,000	26.7	28.55	45	78
2000 kw.	28,800	3,000	9.6	28.1	75	95
5,300	80,000	4,400	18	27.3	44	111
				26.75	84	106
2,500	46,000	1,300	35.4	27.3	54	101
....	15,000	300	50	23½	60	120

Costs in Small Industrial Power Plant

BY C. W. THAYER

When an isolated power plant can be operated at a profit in a district where the hydro-electric interests are well developed, the figures should prove important.

In the present instance, the plant consists of two horizontal return-tubular boilers, with an aggregate rating of 225 boiler horsepower, two steam pumps, one power pump, an open feed-water heater, a draft regulator, and the usual small accessories. The total value of this equipment is $4100. The building is valued at $3000, the 110-ft. chimney at $1200, the boiler and accessories foundations at $150, and the land at $1000.

The fixed charges on the boiler plant are as follows:

Interest at 5 per cent. on total investment of $9450	$472.50
Taxes at 1 per cent. on total investment of $9450	94.50
Insurance on building and equipment	15.00
Special boiler insurance	36.00
Depreciation on building and chimney (1.5 per cent. on $4200)	63.00
Depreciation on equipment (6 per cent. on $4250)	255.00
Repairs on building and chimney (1.5 per cent. on $4200)	63.00
Repairs on equipment (6 per cent. on $4250)	255.00
	$1254.00

The operating charges are as follows:

Engineer, 70 per cent. of time in boiler plant (70 per cent. of 52 weeks), at $22 per week	$800.80
Night fireman, 30 per cent. of time (30 per cent. of 52 weeks), at $18 per week	280.80
Sunday man, 52 days at $2.50	130.00
	$1211.60
Supplies	70.00
Water	100.00
Coal (1100 tons at $4.20, delivered short tons)	4620.00
	$4790.00

The total yearly charge for the boiler plant is $7255.60. With steam at 140 lb. gage, feed water at 200 deg. F., coal containing 14,000 B.t.u. per lb., and a boiler and furnace operating 66 per cent. efficiency, the evaporation is $\frac{0.66 \times 14{,}000}{1022}$, or approximately 9.04 lb. water per pound of coal. The figure, 1022, is the B.t.u. added to the feed water to produce a pound of steam. The cost of evaporating 1000 lb. of water is 36.5c. which is found as follows:

$$\frac{7255.60}{1100 \times 2000 \times 9.04} \times 1000 = 36.5$$

As the demand for steam increases, the evaporation cost will decrease.

The power plant consists of the following items with their corresponding valuations.

Land valued at	$1000
Building valued at	1150
Engine foundations	450
Slide-valve compound engine, 150 hp., direct-connected to a 125-kw. direct-current generator	2800
Generator (125 volts)	1500
Engine piping and separator	700
Switchboard	1000
Apparatus and tools	250
Automatic lubricator and filter	210
Total	$9060

The engine-plant fixed and operating charges are:

Interest at 5 per cent. on total of $9060	$453.00
Taxes at 1 per cent. on total of $9060	90.60
Insurance on buildings and equipment	15.00
Special flywheel insurance	24.40
Depreciation on building, etc. (1.5 per cent. on $1600)	24.00
Depreciation on equipment (4 per cent. on $7460)	298.40
Repairs on building, etc. (1.5 per cent. on $1600)	24.00
Repairs on equipment, etc. (4 per cent. on $7460)	298.40
	$1227.80
Labor (30 per cent. of engineers' 52 weeks at $22)	343.20
Supplies (oil, waste and fuses)	200.00
	$1771.00

The engine is operated 300 days for 9 hr. a day, and switchboard records show the average load to be 140 b.hp. A recording flow meter shows an average of 32 lb. of steam per b.hp.-hr. The steam cost is then

$$\frac{300 \times 9 \times 140 \times 32 \times \$0.365}{1000} = \$4415.04$$

This charge for steam of $4415.04, plus the $1771 for fixed charges, labor and supplies, gives a total charge of $6186.04 for 378,000 hp.-hr., or a cost of 1.63c. per hp.-hr.

In the three winter months all the exhaust steam from the engine is used for heating the plant. As this exhaust will have at least 85 per cent. of the heat units available that are contained in the equivalent weight of saturated high-pressure steam, it is fair to credit this amount to the power plant; hence

$$\frac{\$4415.04}{4} \times 0.85 = \$938.20$$

This reduces the annual cost from $6186.04 to $5247.84 Using this basis, the cost per horsepower-hour is 1.38c.

Eckel Hydrostat Feed-Water Regulator

The Eckel hydrostat for regulating boiler-feed water is illustrated herewith. Fig. 1 shows the device attached to a boiler and piped to a feed pump. The details of construction are shown in Fig. 2. The only moving parts

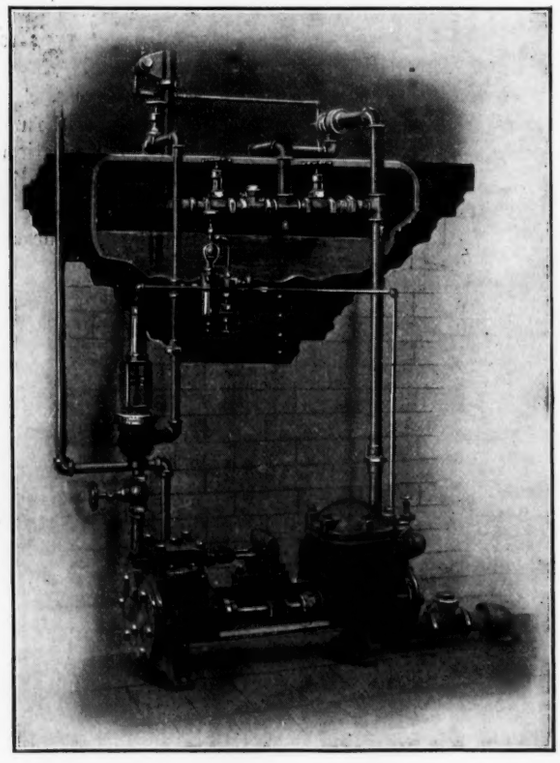


FIG. 1. PIPE CONNECTIONS OF HYDROSTAT AND PUMP

in the boiler are the float, tested to 300-lb. pressure, and the rod connection, which is actuated by the float lever as the water level in the boiler rises or falls.

The vertical rod is incased in the upright supporting stand, and its movement is transmitted to a lever in the casing at the top and on the outside of the boiler shell. This lever is attached to a rod which passes through a stuffing-box and by a series of levers operates a control valve in the feed pipe.

The feed pump is fitted with a governor, controlled by the pressure from the water end of the pump. When the valve in the feed line is partly closed, owing to the

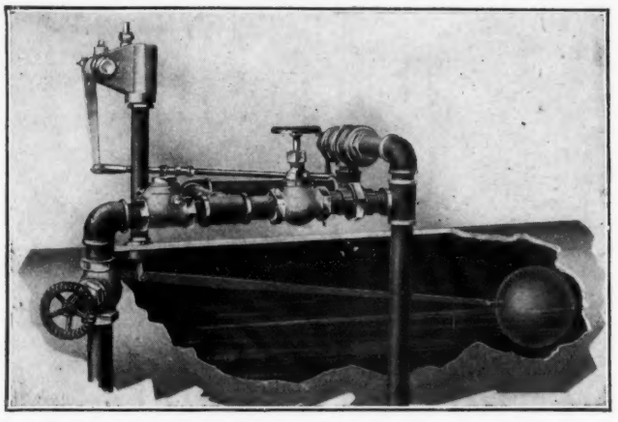


FIG. 2. HYDROSTAT WITH SERIES OF BOILERS

height of water in the boiler, the pressure in the discharge pipe is increased and this pressure is transmitted to the regulator, partly closing it, and slowing down the pump. Fig. 2 illustrates the type of hydrostat used on boilers set in series, where more than one boiler is fed by the same pump.

The hydrostat used with a single boiler controls the

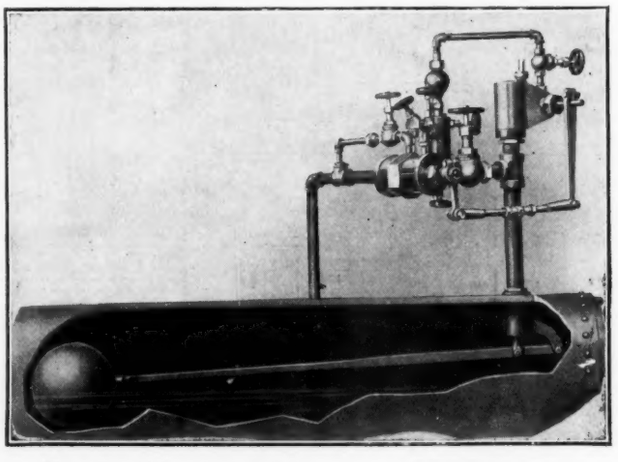


FIG. 3. HYDROSTAT USED WITH SINGLE BOILER

pump speed and no pump governor is used in connection with it, as it is a governor as well as a hydrostat.

The control valve is so designed that dirt cannot stop it from closing, and it works like a shear and is supposed to cut off any matter that might lodge between the ports. The valve does not wire-cut by the passage of the water; the valve is sectional and may be easily taken apart.

This regulator, which is made by the Eckel Hydrostat Co., 458 Mt. Elliott Ave., Detroit, Mich., can be used on any steam boiler.

It Is Contended that fuel can be saved by using higher steam velocities in pipes; the limit for safety with reciprocating engines is 82 to 98 ft. per sec. The Berlin Electricity Works Co. carried out experiments and obtained considerable saving in fuel by eliminating pipes which had been put in to reduce the fall of pressure.—Exchange.

Return Traps for Feeding Boilers

By K. M. Gilbert

SYNOPSIS—Advantages and steam consumption of traps. Explanation of the principle of operation.

Steam traps have been known for many years as a means of feeding boilers, but it seems that they have not been used in small power plants as widely for this purpose as their merits would warrant. For small boiler plants up to 300 hp. a steam trap is an economical and satisfactory means of feeding hot water into a boiler. A good trap requires little attention and no lubrication; it has no piston or piston rods to pack, and but few wearing parts.

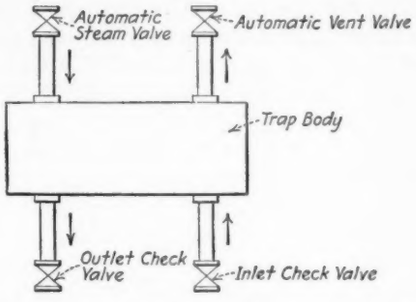


Fig. 1. Diagram of Elementary Trap

For these reasons the repair charges are low—much lower than for a feed pump. For a 100-hp. boiler at full load, a steam trap for boiler feeding would require about twenty pounds of steam per hour; a small duplex steam pump for the same purpose, about one hundred twenty-five pounds. The use of a trap instead of a feed pump would at this rate save 100 lb. per hour, which at an evaporation of 7 to 1 means 14 lb. of coal per hour, or 140 lb. per day for each 100 hp.

There are two general classes of traps, the return and the nonreturn. The return trap is used when it is desired to elevate or discharge the water against a head or pressure equal to or greater than that of the water entering the trap, as for feeding boilers or draining a vacuum system. A return trap has an automatically operated live-steam valve and usually a vent valve, both of which are operated by the action of the trap when sufficient water has entered.

A nonreturn trap has no live-steam connection, and for this reason it cannot discharge its contents against a head any greater than that of the water entering it.

There are several types of traps which, if named according to the method of operating the valves may be called tilting, bucket, float, expansion, and differential. These various types have their advocates, but from the writer's experience of several years he has found that the tilting trap has given the best service. All of its working parts are accessible and within the sight of the engineer, who can tell at a glance how the trap is working.

While the methods of operating the valves of the several traps vary, the principle of operation is the same for all types and, for the benefit of the young engineer, can be explained by aid of Fig. 1. The drip or feed water for the boiler enters the body of the trap through the inlet check valve. When sufficient water has entered, the operating mechanism of the trap is so arranged that either the weight of the water, a float valve, or a bucket, etc., automatically closes the vent valve and at the same time opens the live-steam valve. The steam pressure then acts on the surface of the water in the trap, the inlet check valve closes and the outlet check valve opens, enabling the steam to force the water out of the trap. When the trap is nearly emptied the steam valve is closed and the vent valve automatically opened. The pressure in the trap body is reduced to atmospheric so that the drip water can enter and again fill the trap. From this explanation it should be readily seen that the steam consumption for each discharge of the trap is about equal in volume to that of the trap reservoir.

Fig. 2 shows the arrangement of piping, traps and feed-pump connections to two return-tubular boilers. The feed pump is for use while examining or repairing the traps. The trap discharging into the boiler must be placed about four feet above the water line in the boiler, then when the steam is admitted to the trap this head is sufficient to overcome the friction of the piping and check valves so that the trap is quickly discharged. In all cases the water must flow into the feed trap for, unlike a pump, it has no power to raise water by suction. When by the pressure in the system the water cannot be raised to the feed trap, another trap must be employed to do this work. The low-pressure trap (Fig. 2) is connected to discharge the low-pressure drips into the feed trap. Its action is the same as the feed trap, and the use of the live-steam connection makes it possible to raise the water.

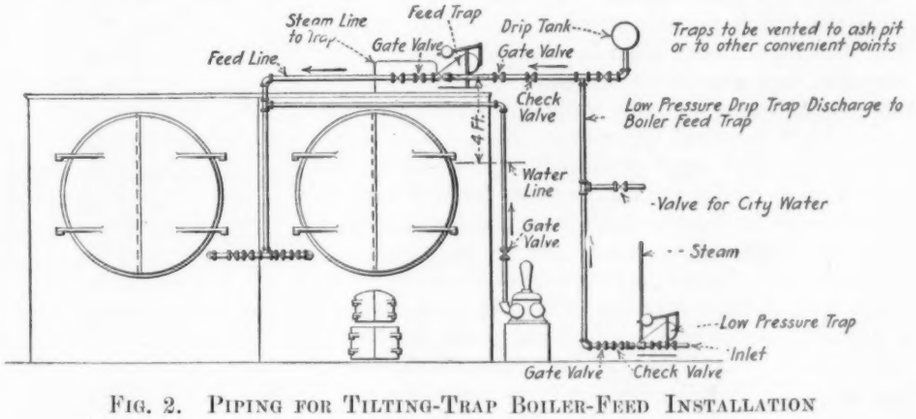


Fig. 2. Piping for Tilting-Trap Boiler-Feed Installation

The pipe connections to and from all traps should be sufficiently large and free from numerous turns. The pipe connections to nearly all traps are too small, and the inlet and discharge pipes should be one or two sizes larger than the trap connections. The inlet pipe line should slope

toward the trap, and the outlet should slope downward in the direction of the flow of water to the boiler. An air chamber on the discharge line will prevent the noise and shock which sometimes occurs from water-hammer.

The check valves should be of the swing type and the others of the gate type. The live-steam connection must be made direct to the boiler shell or as close as possible, so as to have the full steam pressure available for operating the trap, as a pound difference in pressure between the trap and the boiler may prevent satisfactory operation and reduce the capacity of the trap. The packing used around the valve stems should be of soft material and well lubricated. Most of the tilting-trap troubles come from using a hard asbestos packing which in a short time becomes hard and binds the stems. The packing should be braided and well lubricated with graphite.

Slippage of Reciprocating Pumps

By T. B. Hyde

SYNOPSIS—In view of the many different expressions relative to pump slippage which have lately appeared in Power, *the following article will be of much interest to the many concerned with the subject. The volume of slippage depends upon the discharge and suction pressures, condition and tightness of valves and plungers or pistons.*

Slip is a "dead" loss of power. The useful work done by a reciprocating pump is measured by the amount of liquid pumped, multiplied by the head pumped against. This is less than the indicated work of the pump cylinder by an amount equal to the slip. Slip is therefore defined as the difference between piston or plunger displacement and the actual volume of pumpage expressed as a percentage of the former.

Where the pumping unit is large slip is usually closely watched and kept at a minimum, but the same cannot be said of many smaller pumps, particularly those used for boiler-feeding purposes. As an example the writer recently noted a feed pump running with 80 per cent. slip; in other words, its displacement was five times its pumpage; its useful horsepower, represented by water delivered to the boilers, 4.20; its actual water horsepower, four times that, say, 17. The steam consumption, or water rate, of these small duplex pumps is seldom less than 120 lb. per water horsepower-hour, and usually higher. Using this conservative figure for an assumption, this pump was using $17 \times 120 = 2040$ lb. steam per hour, of which 80 per cent., or 1632 lb. (47 boiler hp.), was spent for slip. A feed pump can be handled nicely on 15 per cent. slip, so that there was a clear waste of 38 boiler hp., or in money, roughly, thirty cents per hour. The main units were noncondensing; it was summer and there was an excess of exhaust steam, so there was no justification of this waste.

Slip is greater at low pump speeds than at high. In order to understand this clearly we must differentiate between per cent. slip, or "slip" as it is called, and actual volume of slip. The latter is the difference between displacement and pumpage and is reduced to per cent. slip by dividing by displacement. The volume of slippage depends upon discharge and suction pressures, condition and tightness of valves and plungers or pistons, as the case may be. It may be likened to a leaky globe or throttle valve; the greater the pressure, the greater the amount of leakage; the greater the amount of opening, the greater the amount of leakage. Wherefore, with a given pump, with valves and pistons in a given condition, the actual volume of slip may generally be said to be independent of speed; a function of discharge pressure and time only. But in reducing to per cent. slip, we divide this constant amount by the displacement, which varies directly with speed. Hence, with high pump speed (large displacement) per cent. slip will be low, and *vice versa.*

Slip may be as high as 100 per cent., as is the case of a pump working against a closed discharge valve or a fire pump drifting along at two or three revolutions per minute, maintaining a constant pressure on a sprinkler system. Slip may be as low as zero or even be a negative quantity. In the latter case the pump is actually delivering an amount of water greater in volume than the displacement of the pump itself. When this occurs it is due to the rise in pressure in the suction line when the flow is suddenly checked, forcing water through both suction and discharge valves and into the discharge line. This action is similar to the hydraulic ram, where the velocity of the water being suddenly checked, it is changed into pressure sufficient to force a small quantity of water into the discharge line against a pressure considerably greater than the supply head. This negative slip occurs only under a combination of favorable conditions, among which are high velocity of water in suction pipe with slight suction head, low discharge pressure and tight valves. To produce negative slip the amount of water passed through by this "hydraulic-ram" action must be sufficient to more than balance the normal slippage through the valves.

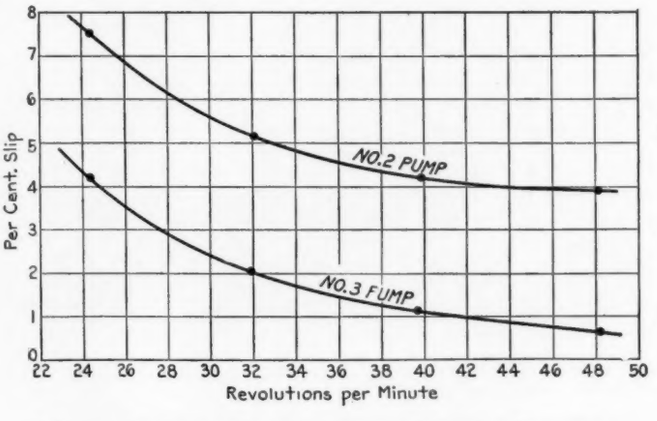


Fig. 1. Slippage-Test Results of Large Pumping Engines

Fig. 1 shows the result of slip tests on two large cross-compound steam-driven flywheel pumping engines. The pump plungers of each unit have a displacement of 306

gal. per revolution. These tests were conducted with considerable accuracy, the water being measured by a venturi meter in the pump discharge line. The discharge pressure was 40 lb. per square inch gage; suction head practically zero. In these pumps, when valves are in good condition negative slip is frequently found at the higher speeds.

Fig. 2 shows a slip test on a 12x7x12-in. steam duplex feed pump. Incidentally, this test was made to calibrate

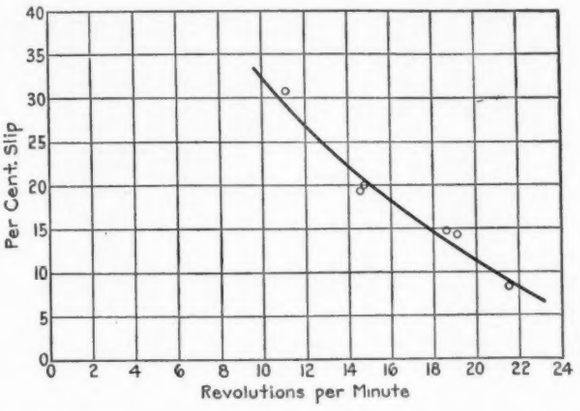


FIG. 2. SLIPPAGE TEST ON 12x7x12-IN. DUPLEX PUMP

the pump, so that a revolution counter could be attached and the pump used as a boiler feed-water meter to measure the station boiler load. Such a slip test is simple and can be made by any engineer in the following manner, without any extraordinary apparatus: Blank off the regular discharge line and pipe the discharge to weighing barrels or, as was done in this case, to a large tank that had been previously measured. Old fire hose was used for piping. Put a throttle valve in the discharge line near the pump and place a pressure gage between the pump and this valve. At whatever speed it is desired to run the pump, maintain the discharge pressure, by means of this valve, the same as that against which the pump normally works. Two other conditions—suction head and water temperature—should be maintained the same, although they are of lesser importance than pressure and speed. In the test referred to, these were taken care of by pumping from the regular feed-water heater through the regular suction line. Live steam should be admitted if necessary, to maintain the normal feed-water temperature. The pump may be calibrated at a single speed, which should be that at which it normally runs, or if desired, the calibration may be extended over a range of speeds, but no comparison can be made between test and running conditions unless both pressure and speed are the same. For accuracy suction head and temperature should be the same, although any change in either, sufficient to introduce any serious error in results, would usually make itself noticeable by hammering of the pump, indicating that the pump was getting either vapor or air.

Duplex steam pumps tend to "short-stroke" at low speeds. Strictly, this should not be charged to slip, for it is neither a waste of power nor of steam. In the above test, however, is was charged to slip, in order that the results of the slip test might be applied to the readings of the counter to obtain the amount of boiler feed. This method of measuring boiler feed can be recommended only for places where suitable meters are not available.

Just for Fun

[*More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.*]

We are pleased to give you the following, which we believe is good enough to publish in POWER

A new salesman was sent out to sell a steam engine. The customer advised him that he would like an engine that would run both over and under. The new salesman explained to him that all he would have to do would be to turn the throttle to the right to make it run over and to the left to make it run under.—*I. N. Beeler, Syracuse, N. Y.*

In a certain felt factory static electricity caused trouble at the cards. I sent an electrician to the plant, instructing him to arrange a "comb" close to the drive belt and connect it by wire to a gas pipe, water pipe, or any conductor that ran to ground. Going to the plant afterward to see if the trouble had been completely removed, I found that instead of being connected to a pipe the wire was run to a pail on the floor, which was partly filled with water. The intention, I was told, was to empty the pail when it became filled with electricity.

In another plant I noticed a pipe with a valve connected to the steam space and running down beside the boiler and through the setting. The engineer opened the valve occasionally. Thinking it might be some new smoke-consuming device, I opened the furnace door to see how it operated and discovered that the pipe was connected to a small bag on the bottom of the boiler. I asked the purpose of the pipe and was told that the mud and scale had a tendency to settle in a bag on the bottom of the boiler and that by means of the pipe he could blow steam into the bag and displace the scale.—*R. McLaren, Medicine Hat, Alta.*

At one time along my trail of bygone experience, I hired out as engineer of a grist mill that was located in a region wherein capable engineers were by no means abundant.

I arrived in the village at supper time on the day before I went to work, and didn't have much of a chance for a preliminary look around. In the morning, when I had everything in readiness, as I thought, for starting the engine and was about to turn on the steam, the colored man who looked after the place at night handed me a stout bludgeon, with the remark: "Heah am yo' stahtah, Boss. Yo' kaint staht dis heah injine 'thout yo' stahtah."

"Starter for what?" I inquired.

"Why, fo' dis heah twadlash," he explained, as he indicated the head-end valve arm.

Sure enough! It wouldn't stay hooked up on the head end at starting, and my predecessor had apparently accepted it as a matter of course that the only thing to do was to keep prying the valve open until the governor rose to a running position. Of course, it was simply a matter of adjusting the safety cam on that end. This I quickly attended to.

At sight of the engine starting off unaided by the hickory stand-by he had offered me, my Senegambian mentor seemed transfixed with the wonder of it, while his ebony visage took on an expression of dumb amazement.

"Laws sakes, Boss!" he exclaimed when he recovered his breath, "yo' sho done chahmed away dat hoodoo, whatevah yo' done!"—*M. D. Conroy, St. Louis, Mo.*

Storage Batteries for Handling Peak Loads

By Everard Brown

SYNOPSIS—Improvement of load factor and plant economy as well as regulation, particularly in the case of hydro-electric generation, where storage batteries are employed to assist on the peaks of the load. Typical load curves show this for different classes of service.

In large central stations for electric power and railway service the use of storage batteries is common. Because of their rather high initial cost, however, this use is somewhat restricted to the larger power plants, although there are some installations among the smaller stations also.

The primary object of a storage battery in electrical-railway service is to relieve the generating apparatus of the larger fluctuations in load by taking care of the peaks that occur at certain periods of the day, and also to act as a reserve in case of a breakdown. By relieving the station of such fluctuations the generating units are free to operate at a steady and, consequently, an economical load. Moreover, storage batteries discharging on the peak loads

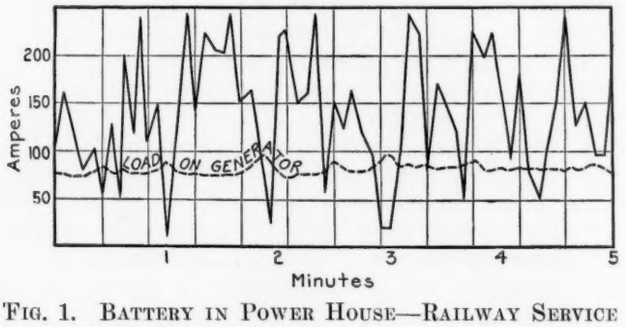


Fig. 1. Battery in Power House—Railway Service

and taking a compensating charge during the period of light load will raise the load factor, thereby improving the economy of the plant; and, by taking slight peaks on an increasing station load, they retard the time of starting additional engines. Figs. 1 and 2 show the fluctuations and peak loads over short periods in railway service as taken care of by a storage battery. In both it will be noticed that the battery is discharging much more than it is being charged. Such a condition occurs, naturally, at times when the traffic begins to increase or lights are put on, but not to such an extent as to warrant the starting up of another generating unit.

Heavy line batteries or battery substations are frequently used on railway and district lighting systems to relieve both the power station and the feeder system, but principally the latter, at times of high peaks. At other times they are used to regulate the voltage and care for the variations in the current. Without batteries the peaks can be taken care of only by extra generating apparatus at the main power station and extra feeders to the center of the load district. The substation battery, being located at or near the point of heavy load, eliminates these requirements and relieves the system of fluctuations, so that the cars or the lights or both, as the case may be, can operate at a steady voltage. The operation of a railway line battery taking fluctuations is indicated by Fig. 3, which shows that current was absorbed and discharged by the battery at very short intervals. In this

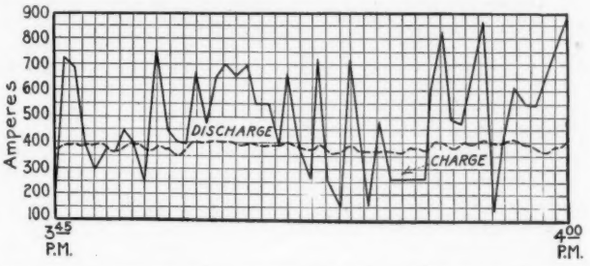


Fig. 2. Battery in Power House—Railway Service

case, however, the discharge is fairly well compensated by the charge.

In rotary-converter substations storage batteries may also be used to advantage. The installation of sufficient storage capacity in such a substation will relieve the converter of current fluctuations, so that the load on the transformers, high-tension transmission lines, and the alternators, engines and boilers in the generating station

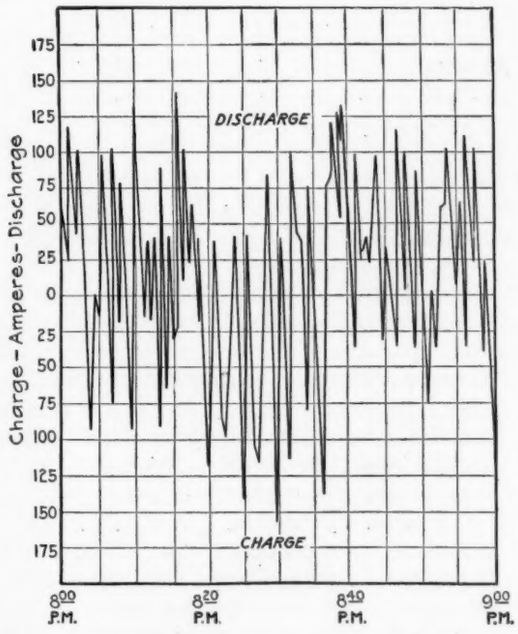


Fig. 3. Railway Line Battery Taking Fluctuations

may be maintained practically constant. An illustration of this may be seen in Fig. 4. The line pressure is maintained between the limits of 450 and 550 volts and is indicated by a nearly straight line. In this curve it will be noticed that the greatest demand upon the substation is between the hours of 6 and 10 in the morning and 5 and 9 in the evening. This is typical of street-railway service. It will be seen that the greatest amount of charging is done between 9 p.m. and 6 a.m., at which time the load is the lightest. Some charging is also done

from 10 a.m. to 5 p.m., showing that the power-generating capacity is in excess of the load requirements during this period.

In hydro-electric plants good voltage regulation is often a difficult matter. At full loads a waterwheel usually

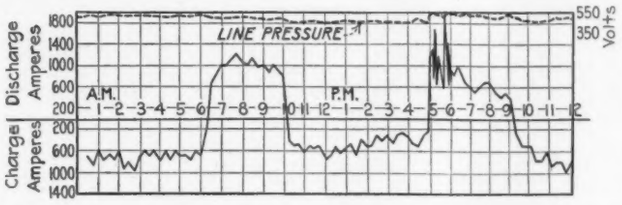


FIG. 4. RAILWAY LINE OR SUBSTATION BATTERY TAKING FLUCTUATIONS AND PEAK LOADS AND REGULATING THE VOLTAGE

takes all the effective water that can pass through its opening at a given head, consequently an overload means a drop in speed. The load variation, moreover, is generally so rapid that the inertia of the water in the penstock prevents satisfactory speed regulation, regardless of how sensitive the governor may be or how ample the wheel capacity. These troubles can be largely overcome by

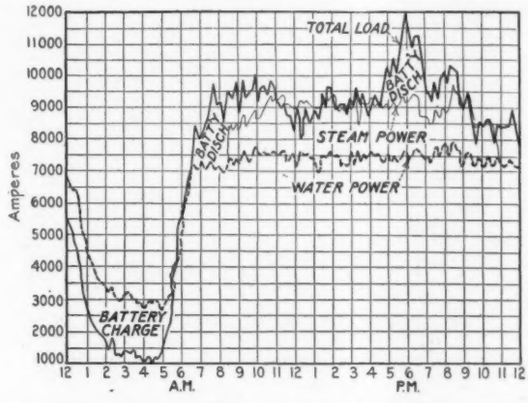


FIG. 5. BATTERY AT RAILWAY POWER HOUSE TAKING PEAKS

the use of storage batteries. It might be said, in fact, that the introduction of such a battery is really equivalent to increasing the capacity of the plant in the same ratio that the peak removed bears to the average load. Results of such an installation may be seen in Fig. 5. In this station as much of the power as possible is generated by water and a steam plant in connection with a storage battery helps out on the peak. From midnight till 5 a.m., it will be noticed, the hydraulic generator had a surplus of capacity above the load requirements, so that some charging of the battery takes place. Then from 6:30 to 8:30 a.m. the battery helps the water power and defers starting up the steam plant about two hours.

For small light and power plants of limited output, Figs. 6 and 7 show what the storage battery will do. In such plants the day load is usually light; therefore, a comparatively small battery will supply current for a large part of the time and the battery can be charged in the evening or early morning, when the plant is in operation. In this manner a day service can be maintained at little expense for labor and with a materially decreased operating cost per unit of output. In addition to this there is the advantage, common to all kinds of power stations, of having an extra source of power ready in case of demand, thus insuring good regulation of the voltage.

In considering the installation of storage batteries the room should really be in a separate building, if possible, away from the rest of the equipment, and in order to keep down the temperature and to free the room from acid spray it should be well ventilated. In some instances it may even be necessary to resort to artificial ventilation by means of a fan or blower if the battery does considerable peak-load work and requires almost continuous charging at certain hours. As the gases given off during the charging of a battery form an explosive mixture if confined, this need of proper ventilation is important, as is also the keeping away of any exposed flame at such a time. In cold climates it is sometimes necessary to heat the battery room in order to obtain the maximum capacity.

In charging a battery the rise in voltage is quite gradual except near the beginning and the end of a charge, when it becomes more rapid. When fully charged the

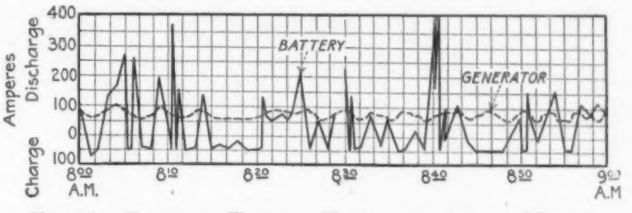


FIG. 6. BATTERY TAKING FLUCTUATIONS OF MOTOR LOAD—SMALL PLANT

color of the positive plates varies from a reddish brown to nearly black and the negative from a pale to a darker slate color. The negative plates, however, are always lighter in color than the positive. Excessive discharging should always be prevented if possible, as it has a tendency to cause excessive heating of the electrolyte and disintegration of the plates. This disintegrating as well as buckling of the plates and sulphating are the most serious troubles incident to the use of a storage battery, but these can be avoided to a large extent by proper attention. Man-

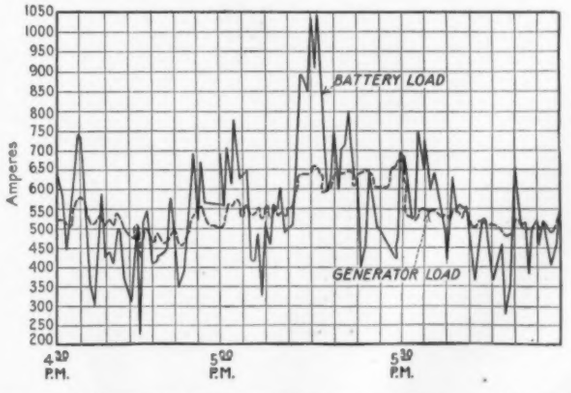


FIG. 7. BATTERY TAKING FLUCTUATIONS AT RAILWAY POWER HOUSE OF LIMITED OUTPUT

agement of a battery installation requires more experience and care, however, than the handling of electric generators, because of the chemical actions which occur in the former and which are more difficult to determine and correct than mechanical or electrical difficulties encountered in the generator. As for depreciation charges, they are somewhat higher, averaging about 8 to 10 per cent.

Safety-First Water Column

The high- and low-water alarm column, Fig. 1, has the outside appearance of an ordinary safety water column. It differs, however, in that it has no floats. Instead, it has two solid metal weights hung one above the other by bronze rods (Fig. 2) from the opposite ends of two bronze levers which rest on a bronze knife-edge fulcrum.

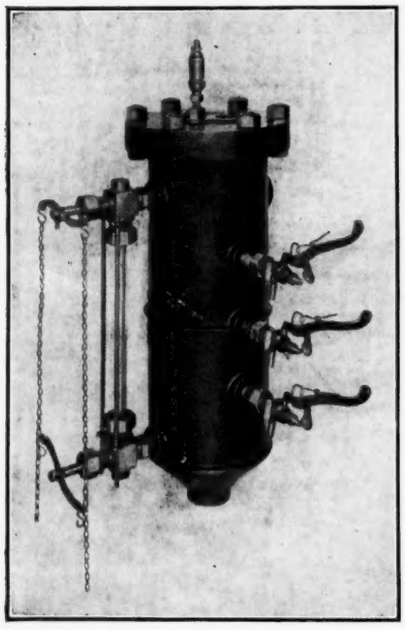


FIG. 1. SAFETY-FIRST WATER COLUMN

The two weights are so designed that the bottom one is the heavier when both weights hang in steam or when both are submerged, as would be the case at extreme low or high water; the top one is the heavier when the bottom one only is submerged, as would be the case when the water level is between the top and bottom gages.

One of the bronze levers is connected to the alarm whistle valve by a knife-edge bearing. The valve and seat are made of monel metal.

Referring to Fig. 2, it is evident that when the water stands at any level between the top and bottom gages, the bottom weight will be submerged and the top one will hang in the steam space. Under these conditions the upper weight will weigh more than the lower one, and will hold the whistle valve closed.

Should the water fall below the bottom gage, the lower weight will weigh more than the upper one, which will rise and open the whistle valve, thus giving the low-water alarm.

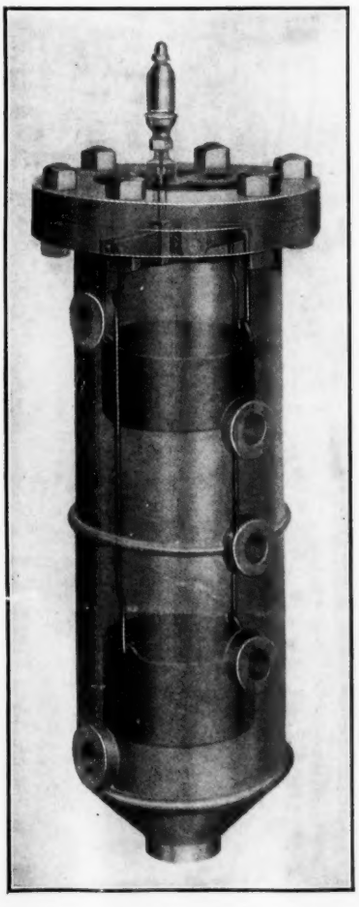


FIG. 2. ARRANGEMENT OF WEIGHTS AND LEVERS

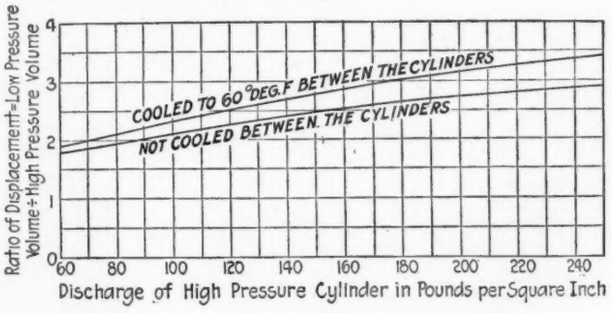
Should the water rise above the top gage, the upper weight will weigh less, and the lower one will overbalance it, which causes it to rise and open the whistle alarm for high water.

This appliance is manufactured by the Engineering Company of Philadelphia, Harrison Building, Philadelphia, Penn.

Cylinder Ratios for Air Compressors

BY F. W. SALMON

Many steam-driven air compressors have to operate at speeds differing greatly from hour to hour to suit the demands for air. This makes it desirable to choose the cylinder ratios of the two-stage air ends with great care, so that the machine may operate steadily and smoothly without danger of stopping on a dead center even at the lowest speed, for naturally, a two-stage compressor will be chosen in most cases to secure economy in power for pressures of 80 lb. or higher, and in the case of large compressors, often for lower pressures.



RATIOS WITH AND WITHOUT INTERCOOLING

The curves show the volumetric ratios required for a two-stage air compressor taking dry air at atmospheric pressure at sea level and delivering it from the high-pressure air cylinder at pressures of 60 to 250 lb. gage, both cooled and not cooled between the cylinders. Moreover, they are calculated to give the same power in the high-pressure cylinder as in the low-pressure.

In various books on compressed air, such as that by Frank Richards, Kent's "Mechanical Engineers' Pocket-Book," and Suplee's "Mechanical Engineers' Reference Book," are given tables showing the horsepower required (neglecting friction) to compress and deliver one cubic foot of free dry air per minute at atmospheric pressure, to given discharge pressures, both isothermally (perfectly cooled between the cylinders and during the compression) and adiabatically (not cooled at all). This given horsepower has been divided equally between the two cylinders and the mean effective pressures calculated for each, as well as the resulting intercooler pressure, which may be aken as the initial pressure for the high-pressure cylinder. Hence the volumetric displacement to meet these conditions could be readily calculated for several of the pressures given, including the 60-lb. and the 250-lb., and a smooth curve drawn through the points so obtained on the chart. This covers the range of pressures needed in over 95 per cent. of the air compressors sold, and it can

be read close enough for all ordinary work, because in commercial practice air compressors are rarely made to bores of fractions of an inch.

Practically all air compressors operate between the limits shown by the two curves. Even in a single-stage compressor the air is cooled somewhat during compression, and yet in the best two-stage machine it is never quite as perfect as isothermal compression; hence in practice it is wise to choose the nearest commercial cylinder sizes that fall between the curves shown in the chart. Of course, one should consider the actual volume of air displaced from each cylinder rather than the piston displacement, as the cylinder ratio depends upon the volumetric efficiency of each cylinder, which is rarely the same for both the high- and the low-pressure cylinders. This is illustrated in the following example:

Assume, that in order to deliver the air required, a 24-in. low-pressure cylinder will be used having a 30-in. stroke and giving a volumetric efficiency of 0.90 for this stroke with the type of valves used. The size of the high-pressure cylinder is desired that will discharge air at 100 lb. gage, with the same stroke, but with a different type of valve which will probably give a volumetric efficiency of 0.85.

Running up the 100-lb. line the best cylinder ratios are found to be 2.11 not cooled or 2.30 cooled. As both cylinders are to have the same stroke, only the areas have to be considered; hence, if A represents the area of the low-pressure piston in square inches and a the area of the high-pressure piston in square inches, then,

$$a = \frac{A \times 0.90}{constant \times 0.85}$$

or

$$a = \frac{452.4 \times 0.90}{2.30 \times 0.85} = 208 \; sq.in.;$$

say 16¼ in. diameter (if fully cooled), and

$$a = \frac{452.4 \times 0.90}{2.11 \times 0.85} = 227 \; sq.in.;$$

say 17 in. diameter (if not cooled).

Thus, there is not much difference, and as explained above, actual practice will lie between these two curves. Of course, if the cylinders are of different strokes, their volumes must be considered instead of their piston areas.

Recedence and Pressure Readings from Submerged Pumps

By G. B. Covington

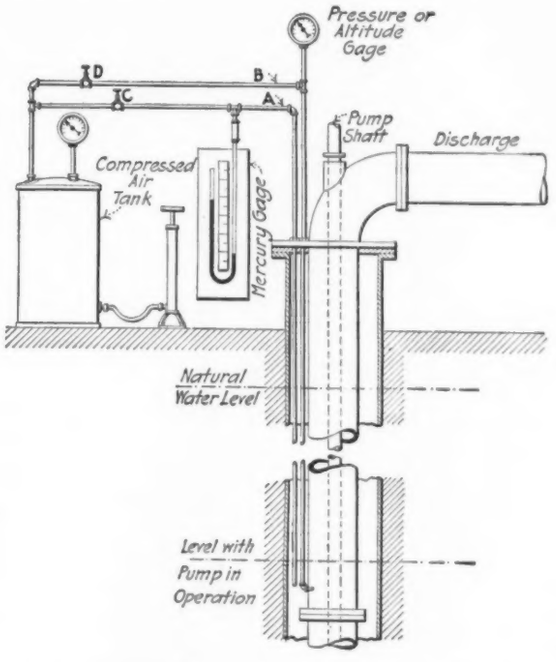
The recedence in level of a deep well, due to its being pumped at various rates, furnishes reliable data as to its capacity. The method of determining the differences in level by an apparatus which may be either constructed as a permanent fixture or made up as a "portable," may be of interest, as in most cases no space is available in the well casing in which to lower a float or other device by which to gage the levels.

For determining the recedence a tube A, shown in the sketch, is let down the well outside the discharge casing, so that the submerged end will be several feet below the natural water level, which, if not known, may be ascertained by experiment.

The tube may be of ¼-in. pipe made up as shown, with valve C for air control and a mercury gage tapped in between it and the submerged tube. Air must first be compressed in the tank (if no service supply is convenient) to a considerable pressure in excess of that due to the submergence of tube A, which may be determined in the following manner: Upon opening the valve C and upon closing the same after a maximum pressure is indicated, the mercury column should recede an amount which will represent the friction of the air in the tube at the rate at which it has been admitted. The static reading is then noted.

Upon starting up the pump or air lift, the operation is repeated, and the difference in the two static readings represents the recedence of the well level. These may be reduced to feet and inches and plotted against "pump delivery."

A similar device for determining the total head under which the pump operates is indicated at B, Fig. 1. The



Method of Determining Recedence and Pressure of Deep Wells

same process of operation will give accurate results with reference to the head under which the pump is working. The friction head without the use of such a device could only be guessed at.

Obviously, all readings must be taken immediately after shutting off the air supply at C or D, otherwise erroneous readings might result, due to a change in temperature of the air confined in the tubes, or slight leakage.

According to the "Electrical World," the main prime mover in the generating station at Independence, Kan., is a double-acting twin-cylinder Strait gas engine, and at one time when this machine was needed to help carry the load an exhaust valve began to give trouble. Shutting off the gas and ignition from the cylinder affected, the men on duty opened the valve chest, took out the defective valve, and replaced it in less than three hours without stopping the engine. The greatest difficulty experienced came from exhaust gases that were discharged up through the manifold from other cylinders. This trouble was overcome by placing a small motor-driven forge blower in such a position that its blast drove these foul gases away from the workmen's faces.

Large Surface Condenser for Commonwealth Edison Co.

The accompanying drawings show the largest Wheeler surface condenser so far built, which is to be installed in connection with a 35,000-kw. turbo-generator at the Northwest Station of the Commonwealth Edison Co., of Chicago.

Looking first at the end elevation, the circulating water entering the station by the inlet tunnel shown at the bottom of the drawing is picked up by the 3½x4½-ft. rectangular suction pipe of the circulating pump. This pipe is in the form of a gooseneck, the top of which is between 11 and 12 ft. above the pump center. The pump is below the water level, but is protected from flooding by this siphon and no valve is needed. A priming pipe shown connects the pump with the water in the riser of the siphon when the small valve is opened, and this enables the pump to pick up its suction and draw the main volume of water over the siphon.

The circulating pump is of the tri-rotor high-speed design for direct-connected drive at 1500 r.p.m. The turbine is a specially designed unit built by the General Electric Co., arranged for driving the circulating pump from one end of the shaft and the air pump from the other, as shown in Fig. 4.

The delivery of the circulating pump is connected through an expansion joint with the water intake of the condenser, and under normal conditions 50,000 gal. of water per minute flows in two passes through the condenser, leaving at the upper left-hand segment in the end elevation, Fig. 1, through a circular discharge main to the outflow tunnel.

Steam is exhausted from the main turbine through a passage about 12x14 ft. in area. The contour of this passage is shown in the plan, Fig. 3.

Upon entering the condenser, the steam first impinges

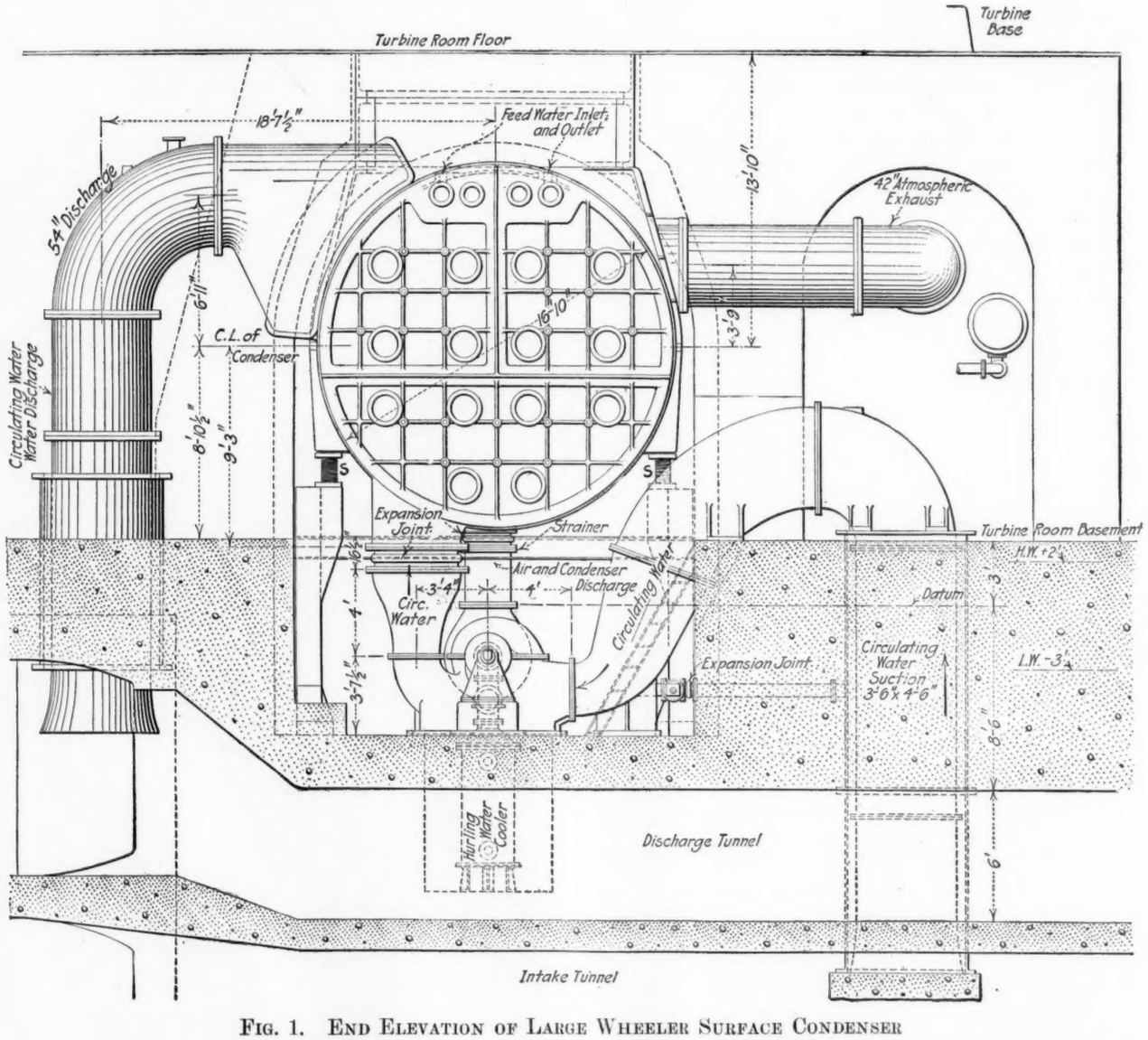


FIG. 1. END ELEVATION OF LARGE WHEELER SURFACE CONDENSER

upon feed-heating tubes arranged at the top of the shell as shown at *AAA* in Fig. 7, through which the condensate is pumped before going to the boiler plant. After giving up part of its heat to these tubes, the steam flows into the condensing space proper, which is arranged with extra wide tube spacing and with the tubes disposed in lines parallel to the flow of the steam. A steam belt extends well below the center of the shell, thus admitting steam well down into the sides of the condenser, all of these features combining to give free flow of steam into and among the tubes. The air is drawn off in the center at the bottom of the condenser through a large outlet pipe, which also carries off the condensate. Baffles *CC* at the sides prevent the short-circuiting of the steam to the outlet.

compression channels; and these plugs, by the momentum due to their high velocity, force the entrapped air before them into the discharge passage against the pressure of the atmosphere. The hurling water enters at *E*, Fig. 5, and is discharged with the air at *C*. In Fig. 2 the combined air and condensate pump is shown at *A*, the hurling water entering at *E* and discharging at *C*, into the well below, the air separating off, the water passing through the cooler alongside, on its way back to the pump. The condensate flows by gravity to the other impeller of the pump at the left in Fig. 5, and is discharged through the pipe *F*, through the heater tubes at the top of the condenser and then to the boiler plant.

The combined Wheeler condensate and turbo air pump

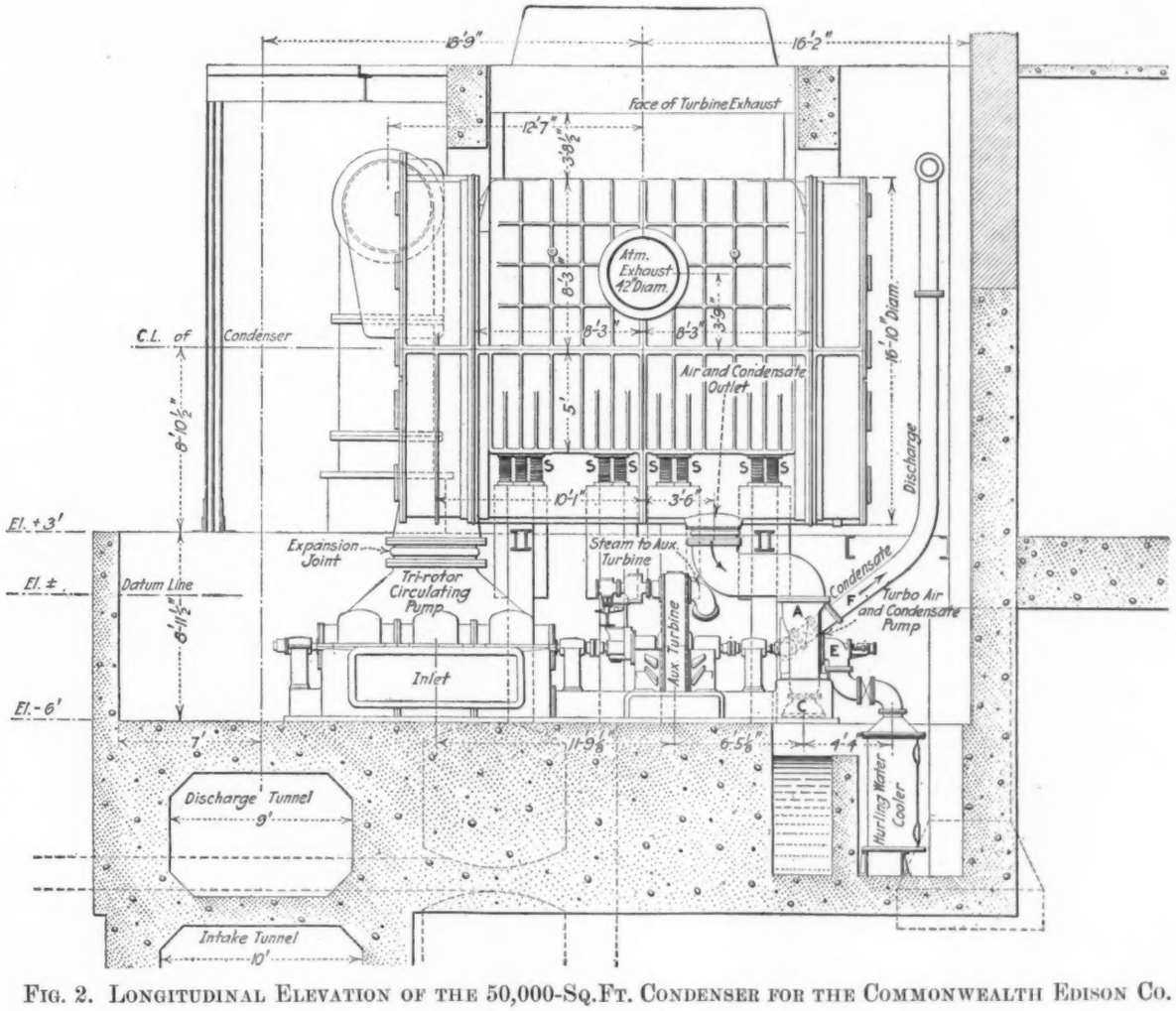


FIG. 2. LONGITUDINAL ELEVATION OF THE 50,000-SQ.FT. CONDENSER FOR THE COMMONWEALTH EDISON CO.

This arrangement of a single outlet for the condensed steam and for the noncondensible vapors is unusual in large condensing units, but was possible in this instance because of the design of air pump which was employed. A section of the pump is shown in Fig. 5. The air and water enter the pump by a common pipe, but are handled separately within the casing. As the condensate enters the chamber *A*, the air turns off from it to the compartment *B*, and is forced out into the chamber *C* by a turbo-air pump impeller shown at *DD*. The action of this pump is shown in Fig. 6. The impeller discharges at high velocity streams of water which are cut into plugs by the sharp edges of the separations of the

is driven by the same auxiliary turbine which drives the tri-rotor circulating pump. Thus the condenser auxiliaries are very much simplified, require less floor space and piping, and less attendance.

In order to allow the condenser free play under varying conditions of vacuum, temperature, etc., its weight is carried upon 18 heavy railroad-type springs, as indicated in Figs. 1 and 2, at *SSS*, the springs resting upon heavy concrete pillars. The shell of the condenser is made of heavily ribbed cast-iron sections, division being horizontally at the center and vertically at the center, making eight sections in all. The weight of shell, tubes, water boxes, piping and contained water will be approximately

200 tons, but this downward force is counterbalanced by an upward force when the vacuum is 29 in., of nearly 170 tons—the upward pressure of the atmosphere on the projected area of the 12x14-ft. opening.

At its maximum capacity this condenser takes care of 400,000 ÷ 50,000 = 8 lb. of steam per sq.ft. of heating surface per hour, which is "some steam" even if it be allowed that 15 or 20 per cent. of it has been

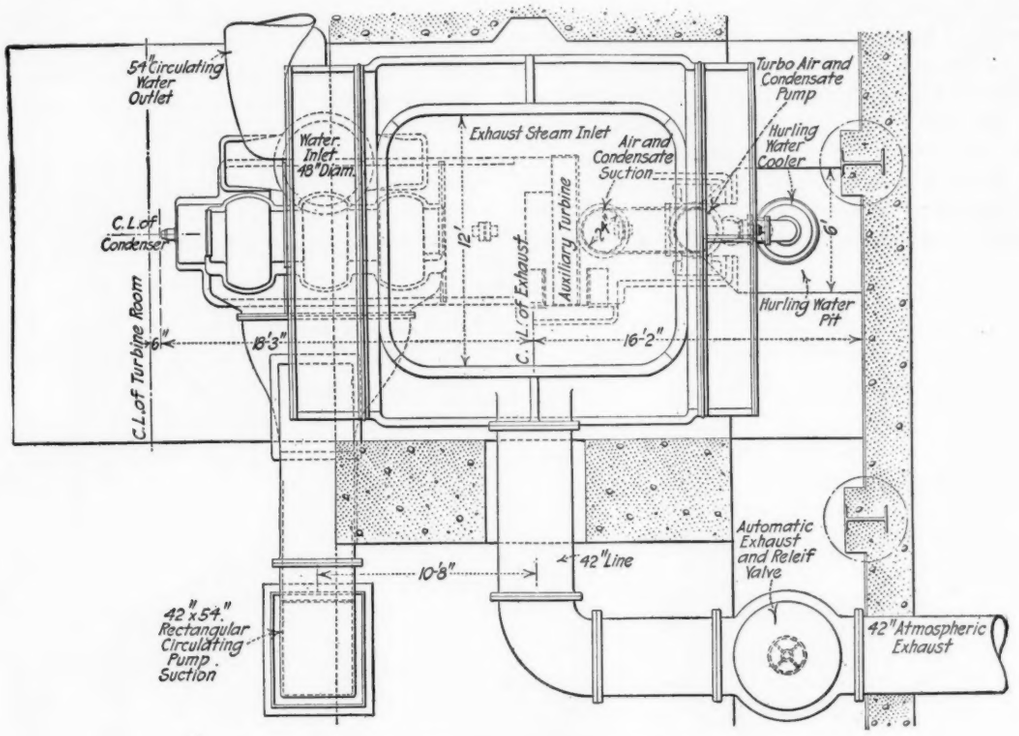


FIG. 3. PLAN OF CONDENSER PIPING AND AUXILIARIES

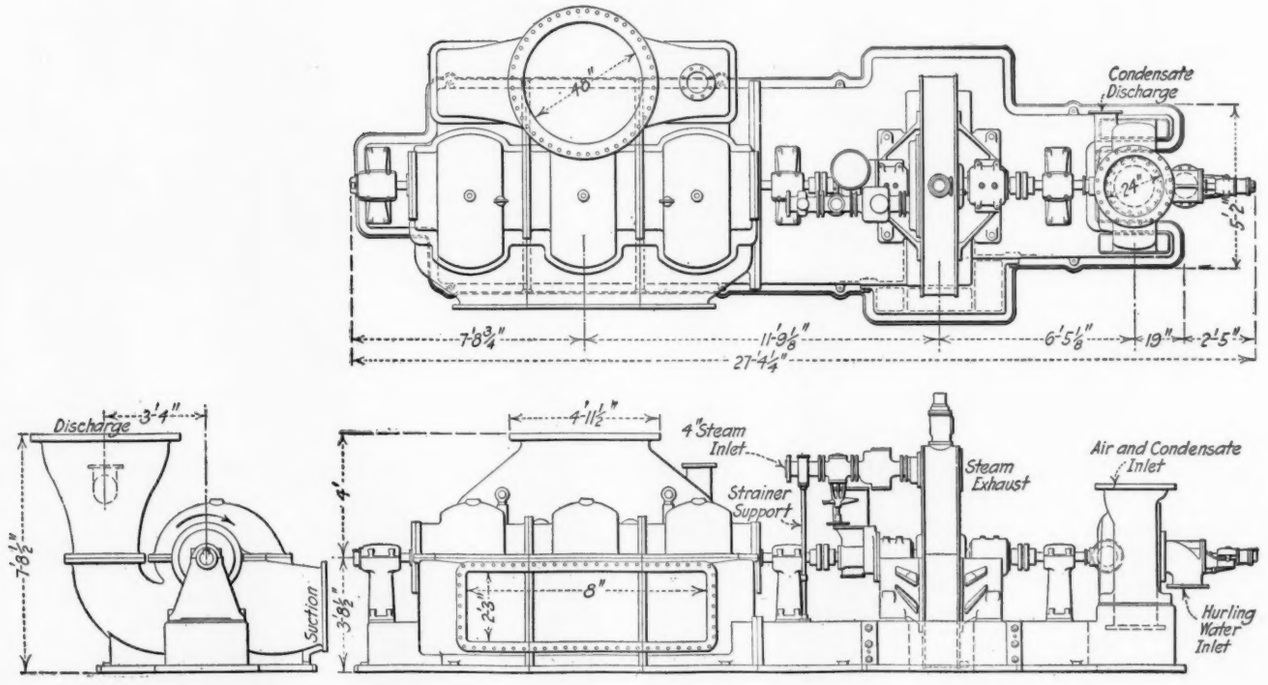


FIG. 4. PLAN, END AND LONGITUDINAL ELEVATION OF TURBINE-DRIVEN PUMPS

There are 50,000 sq.ft. of surface in the condenser, made up of 18 B.w.g. brass tubes. The rated capacity of the condenser is 360,000 lb. of steam with a maximum of 400,000 lb. per hour, and the vacuums to be maintained throughout the year average about 29 in.

already condensed. Imagine an immense pan, 250 ft. long and 200 ft. wide, full of water, over a fire burning with an intensity which would evaporate from every square foot of the water surface over twice as much water as a boiler does at its rated capacity, and you have an

idea of the rate of work which this condenser has to undo.

At 75 lb. of condensing water per pound of steam the condenser would require $75 \times 400{,}000 = 30{,}000{,}000$ lb. of circulating water per hour or over 130 cu.ft. per sec., an amount which with a fall of 10 ft. would develop

$$\frac{30{,}000{,}000 \times 10 \times 0.80}{33{,}000 \times 60} = 121 \; hp.$$

and which flowing at the rate of 2 ft. per sec., a rather high rate for a mill race, would make a stream 10 ft. wide and 65 ft. deep. At 29 in. vacuum, or at an average pressure which would support one inch of mercury, the volume of a pound of dry-saturated steam is 654 lb. At its maximum capacity the condenser handles 400,000 lb. per hour or

$$\frac{645 \times 400{,}000}{3600} = 71{,}667 \; cu.ft. \; per \; sec.$$

which to pass through the 12x14-ft. passage by which the condenser is connected to the turbine would have to have a velocity of 427 ft. per sec. One hundred miles per hour, which is less than 150 ft. per sec., is characterized in the wind tables as an "immense hurricane."

It is true that steam initially at 200-lb. gage, and

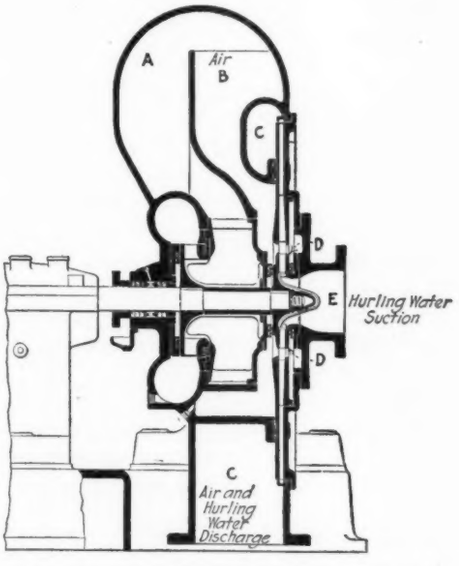


Fig. 5. Combined Condensate and Turbo Air Pump

with 100 deg. of superheat would condense between 20 and 25 per cent. of itself by expanding to 29-in. vacuum, but this is for the academical case of true adiabatic expansion and a 100-per cent. turbine. If the steam rate is 8 lb. per hp.-hr. corresponding to 12 lb. per kw.-hr. and an over all efficiency of 90 per cent. the turbine is converting

$$2546.56 \div 8 = 318 \; B.t.u.$$

from each pound of steam into work, 2546.56 being the equivalent in B.t.u. of a horsepower-hour. Steam of 215 lb. absolute pressure superheated 100 deg. contains 1259 B.t.u. per lb. If 318 of these were converted to work there would be

$$1259 - 318 = 941$$

left. The heat of the liquid at 29 in. vacuum, or 1-in. pressure is about 47 B.t.u., which leaves

$$941 - 47 = 894$$

for latent heat. As the latent heat of dry-saturated steam of this pressure is 1047 the quality would be

$$897 \div 1047 = 85 \; per \; cent.;$$

that is, for the actual case there would be something like 15 per cent. of the steam already condensed when it came to the condenser instead of the twenty-odd per cent. of the perfect turbine, even including the effect of the heat lost by radiation. It is expected that the condenser will be installed and in operation during the coming summer.

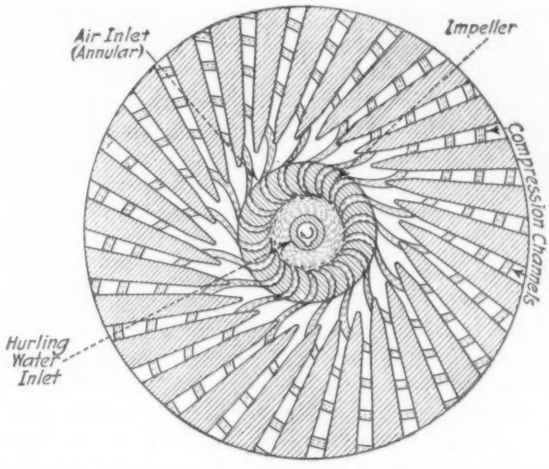


Fig. 6. Showing Action of Turbo Air Pump

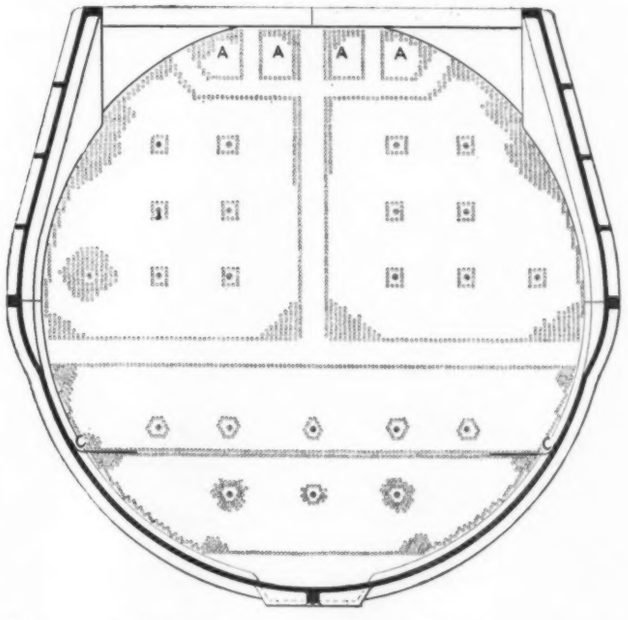


Fig. 7. Showing Arrangement of Tubes and Steam Passages

For the above information and use of engravings we are indebted to Sargent & Lundy, of Chicago, consulting engineers to the Commonwealth Edison Co., and the Wheeler Condenser & Engineering Co., Carteret, N. J., manufacturers of the apparatus.

How Germans Have Crippled French Industry—Dr. Schrodter claims, in a recent issue of "Stahl und Eisen," that although the French territory occupied by the Germans is less than 4 per cent. of the total area of France, it contains 24.8 per cent. of the steam boilers in number, and 43 per cent. in capacity, for 11 of the principal industries the boilers used by which have been shown in recent official reports.

Synchronous Motor in Low-Pressure Turbine Plant

A POWER contributor has written, asking if there was not something unusual in the manner of controlling the synchronous motor mentioned in the article, "Performance of Low-Pressure Plant," in our Dec. 1, 1914, issue. There is not. However, as many readers may be interested to know how a synchronous motor is controlled when driven by a low-pressure turbo-generator and belted to the same jackshaft as the engines which supply steam to the turbine, the following, from the Jenckes Spinning Co., of Pawtucket, R. I., owners of the plant, will be of interest:

"The synchronous motor is belted to the main jackshaft, which is driven by the reciprocating engines. It also runs in parallel with the low-pressure turbo-generator. The turbine is really of the mixed-pressure type, and when first installed the main or high-pressure valve was left open to be operated by the governor. Much difficulty was experienced with the regulation and it occurred to the owners to shut this valve, so that the turbine would never get anything but low-pressure steam. Now, all the governing is done by the governors on the engines. The synchronous motor floats on the line. When the load on the engines falls off and the turbine is not getting enough steam, the load is made up by the synchronous motor being driven as a generator, which, of course, admits more high-pressure steam to the reciprocating engines and more low-pressure steam to the turbine, and the balance is again restored; if the reverse is true, or the turbine is getting more steam than it can use, it drives the synchronous motor which takes more of the load off the reciprocating engine, which cuts down the supply of high-pressure steam and again restores the balance."

Hose-Clamping Tool

A convenient little contrivance for tightening clamping wire about hose, such as is used around the power plant,

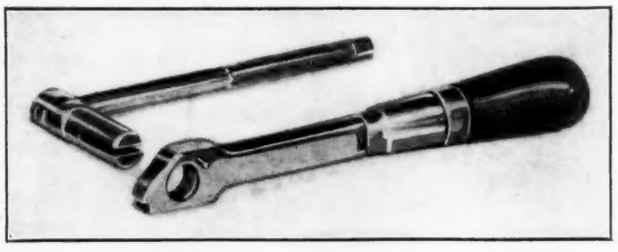


FIG. 1. HOSE-CLAMPING TOOL

FIG. 2. TIGHTENING THE BINDING WIRE

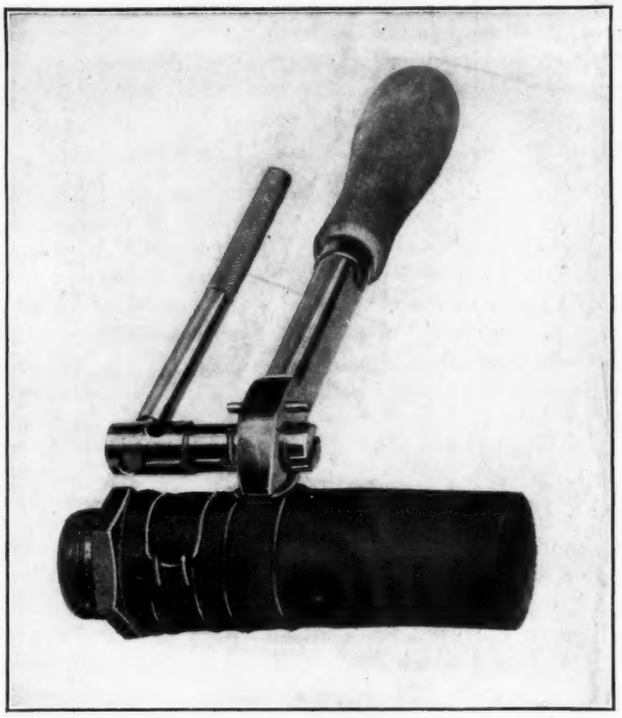


FIG. 3. READY TO TIGHTEN BINDING WIRE

is made by the Wieder Manufacturing Co., Warren, Ohio. The tool consists of holder and handle and a slotted pin in which a lever is fitted, Fig. 1. This pin fits in a hole in the main part of the implement, which has a slotted projection at the end for receiving the binding wire.

The application is simple. The wire is placed in the slotted end of the tool and bent around, the ends coming about even. The device is then placed against the hose and the loose end wound around the hose and passed through the loop in the wire and the slot in the tightener stud, as shown in Fig. 3. Then it is only necessary to push the lever in the direction to tighten the binding wire, and when tight bring the lever over to bind the loose ends over the end, forming the loop, Fig. 2.

Remarks of the Secretary of Commerce—In passing on the case of an employee who complained that he was required to do work beneath his position in the Department of Commerce, Secretary Redfield said:

You may understand it as my views generally in matters of this kind that I do not know what the kind of work can be which is beneath any man's position. I think there is no work of which I know or have heard that it is beneath my dignity to do, and I am glad to say that I have done the plainest and hardest and, what is sometimes mistakenly called, the most menial work, and am ready to do it again if there is occasion for it. There is no man in the department that ought not be willing to do any kind of decent and honorable work whenever circumstances require it of him, and I know of no work with either hands or head which is not both respectable and honorable if done with the right spirit.

The "Storstad" and the "Empress of Ireland"—The action of the Canadian Pacific Railway Co. against the former owners of the Norwegian collier "Storstad" for the ramming and sinking of the liner "Empress of Ireland" in the St. Lawrence is before the Admiralty Court, Montreal. Originally the claim was for £400,000, but this has now been increased to £600,000, the additional £200,000 being, it is understood, to cover actions for damages by loss of life, either on the part of the relatives of the crew under the Workmen's Compensation Act or otherwise. The "Storstad" was sold for £35,000, which was paid into court, and this amount will be available for, and distributed among, all those who substantiate their claims to it. The Mersey Commission fixed the onus of the blame on Chief Officer Tuftness, of the "Storstad."—Exchange.

Editorials

Another Tribute to Engineers and Firemen

One of the chief lessons thus far taught the world by the European war is the importance of speed in naval activities. More than ever before in history, a difference of a very few knots in the ability of a war vessel to cover a course is counting in the final outcome of conflicts on the sea. Nothing less than speed enabled the now famous "Emden" to pursue her career; speed permitted the "Dresden" to escape so long after the battle off the Falkland Islands; and it was this quality again that so prolonged the destructive mission of the "Karlsruhe." Lack of speed prevented the old-style battleship "Canopus" from joining Sir Christopher Cradock in time to avert the disaster off Coronel, and it was speed primarily that enabled Admiral Sturdee's squadron to crush that of Von Spee immediately after reaching the Falklands.

The value of being able to make twenty-eight knots per hour instead of twenty-four has been demonstrated by the battle cruisers of both Germany and Great Britain in the stirring encounters of the North Sea this winter, and it needs no naval expert to put into words the bearing high speed is likely to have any day upon events of supreme historic interest on the ocean. Only a look beneath the surface is necessary to disclose the importance of faithful performance of duty on the part of the power-plant staff afloat, and it is no discredit to the navigating officers or to the men behind the guns to raise one's hat for a moment in honor of the brave fellows of engine room and stokehole on both sides of the combat whose devotion to throttle and shovel, valve and slice bar, amid fearful and unseen perils, is powerfully helping to decide the issues in the greatest struggle known to history.

Relations of the Consulting and the Operating Engineer

A large part of the work of a consulting engineer consists of analyzing conditions in isolated plants, testing their equipment, and advising their owners what to do to improve the service. Often he is called on the advice of the operating man; more often he is not. To have another step in and tell you how to conduct your own business, especially if he is retained without or against your advice, provokes resentment. But this attitude is becoming less general. Often, the man who protests most about the intrusion of the specialist (in our case the consulting engineer) feels that exposure of his weaknesses is imminent, and of course fights against it.

Consulting engineering, like other professions, has its quacks and fakers. But this kind of man soon gets a reputation that does not help him to do more business or to hold the approbation of his fellow engineers. The work of the consulting engineer brings him in contact with a variety of conditions and things which, together with his technical training, give him opportunities to gain experience that the operating man cannot hope to acquire. It is mainly this difference of training which distinguishes one from the other. If it were possible for operating men to receive such training, there would be need of but few consulting engineers.

The chief cause for the ill feeling that so many operating men have for consulting engineers is not merely because one operates and the other advises and plans. Most power-plant engineers appreciate the professional services of consulting engineers, but are too often suspicious of their presence because of petty things experienced or heard about. For example, a consulting engineer may advise that the present engineer be displaced to make room for a friend of his own. Sometimes, this course is necessary in order that the work which has been done, or is to be done, may be properly carried on.

A man who has been placed in his position by a consulting engineer sometimes feels that his employer is having unnecessary work done on the advice of the consulting man, or that the latter is charging an exorbitant price for his services for certain jobs. He is under obligation to the consulting engineer who got him his job, and rather than incur the displeasure of his benefactor by informing his employer of his suspicions, he drugs his conscience with the conclusion that the employer has money enough to stand it and, after all, no real harm has been done. These cases, we hope, are rare.

It is difficult for most operating engineers to judge of the equity of a charge for consulting work; also, without full knowledge of the work planned, it is not always easy to decide that unnecessary work is being done. The engineer who feels that such conditions exist in his plant should acquaint his consulting engineer with his opinions and thus satisfy himself whether he is right or wrong. Otherwise, a decision arrived at by snap judgment might cause him to lose not only his friend but his job.

A consulting engineer should not make a big ado about reducing the labor force in a plant when the good to follow will soon be offset by losses due to neglect because of a shortage of labor. Little mistakes of this sort sometimes lead to long disputes with labor unions and involve more than a commensurate amount of worry, time and money. Then again, it must be acknowledged that in some plants a reduction of the labor force is justified and often proves a benefit to those laid off, because in new positions they can develop their usefulness to a greater extent than would be possible in positions where time killing was the chief occupation.

Operating men sometimes accuse consulting engineers of playing into the hands of a central station. It is difficult to believe that these alleged acts are numerous enough to warrant as much attention as they receive in some quarters. Usually, when a reputable consulting engineer makes such recommendations, he does so because the condition of the plant, the owner's financial

circumstances, and the power consumption all warrant the use of purchased power.

When a plant has been allowed to deteriorate through years of neglect, as some have, and chiefly because those in charge did not sufficiently understand their business, the blame for what eventually happens to it is, first, the owner's, for hiring such poor service, and, second, the engineer's, for not knowing enough of the art of his calling to take care of his own interests.

Granting that consulting engineers are sometimes guilty of malpractice, that some of them stoop to deeds unbecoming a professional man, the conclusion is reached, unwillingly, perhaps, that a great deal of the operating engineer's troubles exist because he does not realize that running a power plant today means more than it did in a past well within the memory of us all. This condition should not exist, for there are many channels open to all for cheaply acquiring the knowledge demanded in modern power-plant practice.

Evils of Low Bidding

In spite of all that has been said and written against these evils, slipshod methods in estimating and underbidding are as common as ever. Nearly every failure can be directly traced to careless bidding and a total disregard of overhead and suitable profit.

Bidding on heating work still seems to be based on so much per square foot of heating surface, and on plumbing, so much per fixture installed. Such methods should never be used except as a check upon a properly made estimate, yet curiously enough, an ever increasing number are still willing to try to make a living by these guesswork methods.

To succeed, every business, great or small, must be operated with a clear conception of overhead expense, or calling it by a better name, the cost of conducting business. This will vary slightly from year to year according to the volume of business done, and should be carefully obtained in percentage upon the cost of the volume done over a given period. Past performance will usually serve as a guide, to be used conservatively in ensuing operations.

Before any article is sold or any work entered upon, the complete cost to the bidder should be known as nearly as possible. First, one should find out just what material is required and its cost, then add the percentage of overhead. The labor required to do the job is the hardest item to estimate accurately; it is usually hard to get away from the allowance of so many hours for fitter and helper per fixture, and if cost cards have been properly kept of previous work, this method is often adopted. It would seem better to analyze each stage of the work and figure on the mean speed of the men, and then check the result by the method mentioned, remembering always that it is safer to over-estimate this item than to under-estimate it. To the labor estimate should be added, as before, the percentage for overhead. The continued difference in bids for the same job and the increasing number of failures show the persistence of careless bidding.

Such ruinous competition works to the moral detriment of the trade as well, inasmuch as the successful low bidder, to come out whole if possible, is tempted to resort to questionable methods in trying to beat the specifications. This reflects on him by the constant disputes, the length of time necessary to collect the final payment, and the knowledge that he will not have a chance to get a repeat order from that customer. Really successful bidders are known better by the number of their old or constant clients, whose good will is the best advertisement possible.

A little missionary work on the part of the technical societies might do something to correct these unfortunate conditions.

The Merit of Individual Effort

The ability to do work above the ordinary is not acquired without special concentration and endeavor. This is what may be called individuality. This characteristic must be developed with several attendant factors if the results are to be what the ambitious worker desires. The expert craftsman of any kind needs that individuality, for he uses his brain as well as his hands. For several reasons this attribute is often highly developed in the man who operates or works in the smaller plant.

There is an abundance of commonplace workers and their position has become precarious, for they are in danger of losing their individuality and power to rise higher than their fellowmen. The man who operates a plant of medium size need not fear being eclipsed by the man who operates the big plant, for in the latter, individuality may be smothered in the volume of work. All depends upon the man himself; he must prove his ability for higher-grade work. If his plant is small and his workers few, he has the greater opportunity to show his individuality. Where resourcefulness and work of the higher grade are sought, one looks to the expert rather than to the utility man.

The man operating a moderate-sized plant is better able to realize his ideals. His operating costs are low, he has only a small force, and his overhead expenses are small. Given these conditions, if his service deserves it, there are not the usual obstacles to his getting sufficient remuneration to more than pay for his seeming limited place in the industrial world. He can give such attention to details that his work will be a source of satisfaction and pride. It should be understood that he must hire only such men as will become an inherent part of his individual operation. This makes the genius, the man who has striven to rise above the ordinary work, an eager worker, and one who can in this way develop his latent powers to excel those who are in the ruts of contentment.

With a limited number of machines and a power that can be supplied at low cost, the operator of the small plant has an opportunity to compel attention. Let him specialize. There never has been a greater demand than exists today for the specially expert. To gain recognition calls for courage, concentration, labor and stability. The man who shows these qualities, no matter how humble his position, is bound to rise.

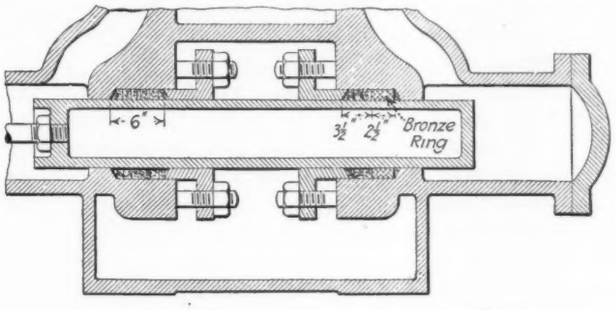
It is greatly to be regretted that Congress failed to approve the two hydro-electric power bills before adjournment. This failure, of course, means that another year of inactivity must pass before anything can be accomplished. Meanwhile the mills are not grinding with the water that is passing.

Correspondence

Depth of Stuffing-Box

The illustration represents the packing-boxes on an outside-packed pump, which was not satisfactory on account of leakage. This pump works on 150 lb. steam and a vacuum of 25 to 26 in. When the packing is tight enough to stop the leak the pump will labor and tremble as if under a very high pressure. Is this due to the deep packing-boxes? Each stuffing-box is 6 in. deep, and the 12 in. of packing, when tight enough to prevent leaking, causes a great deal of friction besides the pressure and vacuum duty.

My suggestion is to replace 2½ in. of the packing-box with a bronze ring made to fit the stuffing-box and



PROPOSED BUSHING FOR STUFFING-BOX

the plunger closely, but not tight enough to cause friction, and to fill the other 3½ in. with three rings of soft square flax packing, thus reducing the total amount of packing from 12 to 7 in. I believe this will permit us to tighten the packing and stop the leaking and still allow the plungers to work freely. I have reduced the number of rings on other pumps from four to two and found that they work better with less power. The packing lasts just as long, and the lining lasts longer than when four rings were used.

CHARLES E. SHERMAN.

Manasquan, N. J.

Priming a Centrifugal Pump

The article in the Mar. 2 issue, page 294, on "Priming a Centrifugal Pump," by J. F. Jones, is interesting. Many would like to know more of the details of this unique installation, accident, and repair. In the first place, will Mr. Jones tell how far above the lower water level the pump was and how high the water had to be elevated to reach the irrigating flume? I suppose the dimension of the pump (30 in.) refers to the diameter of the suction and discharge pipes; and this and the capacity (25,000 gal. per min.) stamp the machine as belonging to the class of large pumps. Will Mr. Jones also tell whether he had any trouble with the side thrust from the unbalanced condition implied by the use of one feed pipe? The principle of priming this pump, though a rather large one, should apply to smaller pumps, with which we have all had our troubles.

I have seen centrifugal pumps which were said to work without priming over a suction rise of 6 to 8 ft. These were only 5- or 6-in. pumps, delivering 1000 or 2000 gal. per min. to a discharge rise of 5 or 10 ft. In my experience I have almost invariably had to prime centrifugal pumps, and my experience covers several, from small ones to 10- and 12-in. pumps throwing 4000 gal. per min. to a height of 50 ft.

The tricks of priming were many. One of the easiest was to let enough water from a storage tank flow back to cover the blades of the pump, and then start, when almost invariably, it would pick up the load at once. There was a check valve below the pump, which, of course, made matters much easier than the conditions described by Mr. Jones. He certainly used his wits in sealing the discharge end with the revolving impeller beating the water that remained in the discharge pipe, and then catching the pump with enough vacuum from the steam ejector to raise the water from the intake below the pump. It would be interesting to know the maximum lift for which this method of starting a pump with steam ejector would apply, and still more so to know just how high this particular pump did work, for it is true, in my experience, that such tricks as this of Mr. Jones' are comparatively easy with small pumps, but become increasingly difficult with increasing size of the pump.

The matter of the collapse of the discharge pipe, built to stand 150 lb. internal pressure and failing under less than 15 lb. external pressure, is also interesting, and I hope that experienced pipe men will favor us with some good common-sense explanation.

CHARLES S. PALMER.

Newtonville, Mass.

Analyzing the Plant's Condition

The report on the condition of the plant under the care of J. C. Hawkins, in the Feb. 16 issue, is interesting and instructive. It also tends to develop enthusiasm, and this alone helps more than anything else to maintain high efficiency in the plant.

The questions in the "New Years Letter" (Jan. 19 issue) cover nearly everything, but a few more might be asked:

1. Is the coal-storage pit moisture-proof? If it is not, much time and labor are lost from too much moisture in the coal.

2. Is the distance between the storage pit and the furnace as short as possible? If not, there is a further loss in time and labor, also wear and tear on extra machinery.

3. Is the percentage of the redeemed waste heat, that is, the heat in the chimney gases and in the exhaust steam, high or low?

4. Have we all the tools necessary for emergencies? If we have, the length of shutdowns will be minimized.

5. Are we using the right grades of cylinder and machine oils?

6. Is all the lubricating oil handled without waste—the proper quantity in the right place at the proper time?

7. Are the suction heads on the boiler-feed pumps right to allow the pumps to operate economically? And are all the pumps operated at the speed conducive to a low percentage of slip?

8. Is the friction horsepower of the plant as small as possible?

SAMUEL L. ROBINSON.

Providence, R. I.

Blocking Up the Governor

It is to be hoped that none of the readers of POWER who operate engines will blindly follow the reasoning in the letter under the above title on page 347 of the Mar. 9 issue, without proving for himself what the effect might be under the various conditions that could arise in the operation of the plant. It will probably not add to the store of knowledge of the average engineer to tell him that the governing of a single engine in a plant where two or more are operating, could be dispensed with provided the load on the plant were always to be more than the maximum capacity of the ungoverned engine and the transmission means between the engine and the load could be depended on to be always in order.

The writer is not an operating engineer and does not want to pose as having superior knowledge in regard to power-plant operation, but unless street-railway power-plant practice has changed remarkably in the past fifteen years, it would seem foolish to say that anyone could guarantee a fixed load for any specified interval during the period of peak loads, when the circuit-breakers are apt to be most active. About fifteen years ago I had some experience in street-railway operation as an engineer, and at peak-load periods had to block the governors on some of the engines to prevent them from dropping. I was an uneasy individual until the load decreased sufficiently to allow the governor-blocking devices to be removed.

If any engineer is forced to operate under similar conditions, even for a limited time, I would advise him to be just as uneasy. If a governor on an engine should become deranged through the breaking of a belt or from any other cause, he should quickly stop it until repairs are made.

There is no class of power plants, as far as the experience of the writer goes, where the load is so likely to be changed from maximum conditions to no load at all, as in street-railway power plants, and if any reader intends to operate such a plant with the governors blocked, as a steady practice, it might be well to block the circuit-breakers, so that they also would be inoperative.

While it is a criticism based purely on snap judgment, the method of applying steam below the dashpot piston of the average governor equipment would not seem to be practical. In the first place, one would expect that when this device operated, the engine room would be showered with oil from the dashpot, and also, that if the piston were as loose fitting or had the area of holes through it usually required to make the operation of the dashpot satisfactory, a ⅜-in. pipe could hardly be expected to furnish a sufficient volume of steam to insure the raising of the governor weights.

However, as stated above, this criticism is not based on actual experience with the device, but since the force of gravity can be had in unlimited quantity and is sometimes used as a pilot to cause the operation of the device as described, it would simplify the apparatus to omit the steam connection and allow gravity to do all the work through a suitable arrangement of levers.

J. E. TERMAN.

New York City.

Uniflow or Una-Flow

Referring to the editorial on page 201 of POWER, Feb. 9, 1915, I should like to add to the discussion the results of a little research on my part.

If you will turn to your Latin dictionary, "Andrews' Latin-English Lexicon," for instance, you will find: *"Una"* (adverb) = in one and the *same* place, or at the *same* time. This seems to be the only form of *unus* which has a distinct sense of *same*. It seems to me that this would make the spelling "una" more nearly equivalent to the German *"gleich."*

The hyphen in una-flow seems to me essential in view of the fact that the use of an adverb would imply that the word "flow" had the strength of a verb.

If the above does not entirely supply the "more subtle" or logical reason for calling the engine by the name "una-flow," which Mr. Alexander finds lacking, we at least are willing to take the additional trouble which the unusual way of spelling entails in view of its advertising value as a unique (unaque) form.

CHARLES C. TRUMP,
Stumpf Una-Flow Engine Co.

Syracuse, N. Y.

Grouting under Heavy Machinery

Some erecting engineers use iron chips or filings and ammonia water, instead of cement or sulphur, for grouting under machinery.

This grout does not set like cement and its action is different. After the ammonia water evaporates, the filings rust quickly and combine into a mass that is about as difficult to chip as cast iron. The engine or other machine is held up on wedges until the filings are hard, and the wedges may then be removed and the holes filled in with the same material.

S. F. WILSON.

New York City.

Referring to the article on this subject by D. N. McClinton, on page 310, in the issue of Mar. 2, he states that it is a matter of considerable discussion whether the leveling wedges should be left under the machinery permanently. From a number of years' experience in erecting engines, I would strongly advise never to leave them in; furthermore, they should be taken out before the grouting has set hard.

A method that I practiced with good results during the last few years of construction work, was to set the bedplate on four wooden blocks a trifle higher than the position desired and close to the anchor bolts nearest to the balancing point of the two ends of the bedplate. Then these bolts were pulled down until the proper height and level were obtained; the wooden blocks would squeeze

enough for this. Then the tension on the bolts was removed and the grout was poured in. I found that one part cement and two of sand made the hardest and most lasting grout. When the cement is hard the wooden blocks will give enough so as not to interfere with the proper tightening of the machine to the foundation, but iron wedges will not. Balancing the bedplate at the two heaviest points eliminates much of the danger of springing.

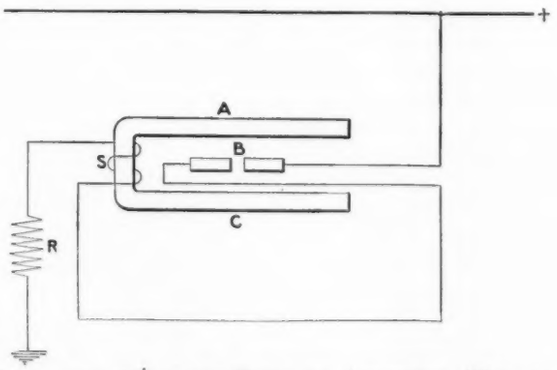
One of my early experiences in the erecting field was replacing a broken shaft of a vertical-engine generating set that had been installed less than two years. The old shaft was removed and no apparent cause for its breaking was discovered at that time. The new shaft was put in place and the engine reassembled. When about to replace the outboard-bearing pedestal it was noticed that the engine and shaft were low. As new bearings were put in with the shaft, it was at first thought that the upper shells were not of the same thickness. These, however, lined up all right. The engine was then raised from the bedplate and it was found that the outboard-bearing end was $^{29}/_{64}$ in. higher than the engine bed. When the bedplate was raised and the old grouting removed, an iron wedge was found driven tight under the part on which the outboard-bearing pedestal was set. No other wedges were found, showing that an inexperienced erector in leveling the outfit had used the generator end of the shaft for a leveling point and had driven the wedge under the small end, springing it up until the shaft showed level. It was surprising that the shaft ran so long without breaking. This incident occurred about eleven years ago, and the shaft then put in is still doing duty.

L. M. Johnson.

Emsworth, Penn.

Modern Lightning Arresters

I have read with interest, "Modern Lightning Arresters," by Charles C. Raitt, in the Dec. 22 issue. The article gives an excellent review of the subject, together with cuts of modern types of arresters, but I would like to call attention to an error in Fig. 11, which is a diagrammatic sketch of a magnetic blowout type of arrester for direc-



Magnetic Blowout Type of Arrester (Fig. 11)

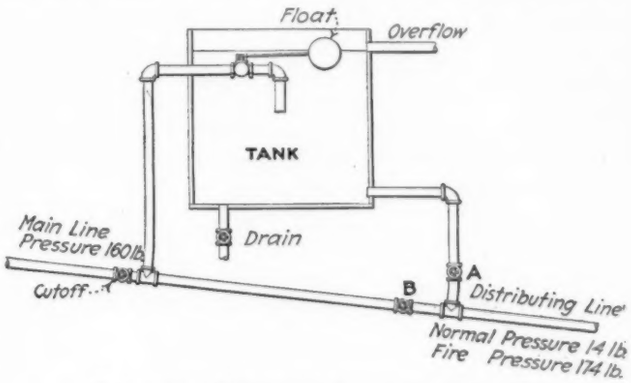
current circuits. The sketch as published shows the lightning-arrester discharge path passing through gap *B*, through coil *S*, and to ground through the resistance *R*. One of the fundamental principles of lightning-arrester design is to eliminate inductance from the discharge path, consequently the magnetic blowout-type arresters as actually designed do not have the coil *S* in series with the discharge path, but are arranged so that this coil is in shunt with the whole or part of the resistance *R*. In other words, the discharge path from the line is through the gap *B* and resistance *R* to ground. After the abnormal potential has broken down the gap *B*, the direct dynamic current follows and the field is built up by the coil *S* which blows the arc *B* from its normal path and extinguishes it by virtue of its elongation.

V. E. Goodwin.

Pittsfield, Mass.

Leaky Valves in a Water System

In a certain mining camp receiving its gravity water-supply under a 400-ft. head, the valves of the hydrants, about 200 in all, were cut by grit in the water after a few weeks' service. A tank was placed at a point about 30



Tank and Float to Control Pressure

ft. above the highest hydrant. The water was allowed to flow into the tank under the control of a float-operated valve and thence into the distributing system, as shown in the illustration.

High pressure for fire protection was provided for by closing valve *A* and opening *B*.

H. M. Howell.

Los Angeles, Calif.

Good Treatment, Good Service

The human, man-to-man treatment of firemen is being successfully applied at the Mechanical Rubber Co., Cleveland. In short, the firemen at this plant, in the words of the operating engineer, George Lowe, "cannot be driven from their jobs."

The plant contains three hand-fired and three stoker-fired boilers, ranging from 220 to 420 hp. The men are paid a bonus on the CO_2—20c. bonus per 10-hour shift for 9 per cent., 30c. for 10 per cent., 40c. for 11 per cent., 60c. for 12 per cent., and 75c. for 13 per cent. The last figure is frequently reached.

The men have been provided with arm chairs in the firing room and a shower bath near-by. "I believe we are successful with our firemen," says the chief engineer, "because we treat them as men and place them on their own responsibility. There is no question of driving them. They work as if they had an actual financial interest in the success of the plant, as indeed they have."

This attitude toward the firing force is only a reflection of a general spirit of progressive efficiency through-

out this plant. In the past year or so, by the application of the system mentioned and its resultant increase in efficiency, by installation of other stokers under the three stokered boilers, which enables them to burn coal at $1.85 instead of at $2.40 per ton, and by the installation of a suction ash conveyor eliminating five ash wheelers at $2.50 per day, this power plant has saved over $18,000 per year net.

E. W. Waldron.

New York City.

Tank Vents

The vapor pipes from return tanks, blowoff tanks and open heaters should each extend separately through the roof; otherwise, blowing down the boilers may cause a back pressure on the other tanks. Where separate lines are impractical, check valves on each line joining the vent from the blowoff tank will prevent back pressure, but they will cause a slight resistance, due to the weight of the check. Such check valves should be so located that no condensate can accumulate above them, because it will tend to hold the valve closed and may at some time freeze.

All outlets such as those from feed-water heaters should empty into a funnel in order to make noticeable any excessive waste of water to the sewer.

T. W. Reynolds.

Mt. Vernon, N. Y.

Trip for High-Voltage Switches

Referring to the description of a "New Series Trip for High-Voltage Oil Switches" in the Mar. 2 issue, I would say that we have such a switch installed on a 60,000-volt circuit.

We found that the wooden rod running from the relay to the trip coil on the operating lever was of such small material that it buckled under action and made the switch late in opening, so that the switches on the low-tension side of the transformers opened first.

This was remedied by putting an ordinary tube insulator half way up the rod, thus preventing it from buckling in the center.

J. B. Crane.

Duluth, Minn.

Paints for Engineering Purposes

In your issue of Feb. 16 appears an article by E. W. Percy, entitled "Paint for Engineering Purposes." To some of the assertions made in this article I believe anyone with a technical knowledge of paint and painting would feel impelled to make objection.

I find myself at variance with Mr. Percy's statement that pure white lead and boiled linseed oil are unequaled for purposes of protection. As a matter of fact, I am sure that there are many combinations that are better. Even for white work many believe that white lead is improved for protective purposes by the addition of other pigments. Be that as it may for white paint, there are at least half a dozen colored pigments that protect better, last longer, and cost less than any white paint.

The usual substitute for white lead is not zinc, but barytes. The zinc is used to give a good color and, when lead is also used, to improve the wear of the latter. Whether it does this or not is a subject of controversy, but I am convinced that it does.

Red lead is not "cheaper than" white lead, but much dearer, because it covers less surface, pound for pound. It does protect steel excellently—but "there are others."

Mr. Percy is sadly "off" in his varnish technology. Varnishes are usually made with fossil gums (resins and not rosins) that were once tree gums, as Mr. Percy states, but which probably have not been in contact with a tree since man appeared on the earth.

Amyl acetate is the orthodox solvent for pyroxylin. I quote from Worden a typical lacquer formula:

	Lacquer, Ounces	Thinner, Ounces
Pyroxylin	5.5	
Amyl acetate	45	40
Refined fusel oil	7	6
Wood alcohol, 97 per cent.	24	35
Benzine, 62 deg.	32	20
Benzine, 71 deg.	20	27

"Metallic Paints," by long established usage, are certain iron-oxide paints made either by grinding native hematite ores or, indirectly, by roasting certain native ores until the iron content is completely dehydrated and converted into ferric oxide. They are red or brown in color. The type of paints to which Mr. Percy refers are known in the trade as bronzes.

The copper paint used on ships' bottoms is usually the oxide or finely divided metallic copper (copper scale).

G. B. Heckel.

Philadelphia, Penn.

More about Graphite

In a plant in Pittsburgh we have five vertical water-tube boilers, each rated at 310 hp., working 24 hr. a day at 25 per cent. over rating. After the use of graphite for some two months we found it necessary to open these boilers about once a week and inspect them by running a light through each tube, as the scale was coming off in such quantities and in such large pieces that it was liable to block some of the tubes and interfere with the circulation. After using graphite four months, our boilers were clean and free from scale. Before using it we were compelled to clean them completely every six months and the front bank of tubes every 30 days. This was expensive, as shown by the following figures. When we were cleaning the boilers with an air-driven turbine it cost about $1300 a year, besides having them out of service from 30 to 60 days each year. Since we have used graphite it has cost us about $475 a year, and we have the use of the boilers continuously.

When we started to use graphite we fed 3 lb. per 100 hp. per day of 24 hr., and after the boilers were clean we cut down the amount to 1½ lb. per 100 hp. per day of 24 hr. Every time we wash out a boiler, which is every 30 days, we put 3 lb. of graphite in the rear steam drum.

John L. Armstrong.

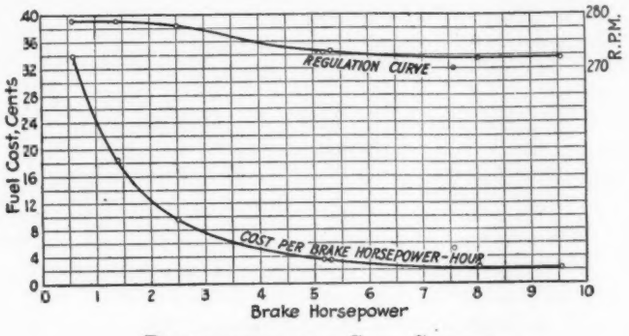
Pittsburgh, Penn.

Correction

Mr. Wentworth's discussion of "Oil Engine Tendencies" in the Mar. 16 issue, page 383, contains the statement: "I have demonstrated that for a running engine 150 lb. is sufficient to ignite the fuel, the hot plate being needed only for starting in the engine which I have developed." The latter part of this sentence should have read: "The writer has developed a type of engine not limited in size and which needs *no* hot plate."—Editor.

A Gasoline-Engine Test

The accompanying curves show the results of a brake test on a 10-hp. gasoline engine, made to determine the cost per brake horsepower per hour under different loads and, incidentally, the regulation under these loads. The gasoline pump was disconnected and the gasoline was fed to the vaporizer by gravity from a 5-gal. can provided with a nipple and cock; the flow being regulated so that only a small amount appeared at the overflow. This was



REGULATION AND COST CURVES

collected and poured back into the supply can, which was weighed at the beginning and at the end of each run. The revolutions per minute were taken almost continuously by speed indicators and the average readings were used in the calculations. Each run was of 30 min. duration, which, although not long enough to obtain extremely accurate results, was sufficiently accurate for the purpose. The cost is based on gasoline at 15c. per gallon.

R. S. HAWLEY.

Golden, Colo.

Lignite in Deep Furnace

A plant owner purchased two 72-in. by 20-ft. high-pressure tubular boilers to be erected in the West. One of them was to be equipped with shaking grates, the other with a special grate and furnace using forced draft through a sealed ashpit and also through a hollow bridge-wall. This type of furnace had been successfully installed in other plants using Wyoming lignite, the coal to be used in the new plant. The advantage claimed for the special furnace was the admission of enough air through the fuel bed to burn it to CO, which, rising above the bed, mixed with the warm air entering through the hollow bridge-wall and burned to CO_2.

In arranging the details of the plate-steel boiler fronts, the contractor's representative noted that the special furnace required a height of 54 in. from grate to boiler. This required the boiler to be set much higher than usual; so to make the fire-doors of all boilers the same distance from the floor, he raised the second boiler so that the furnace height was also 54 in.

Test runs on both boilers were conducted and the boiler with the special furnace showed an evaporation of 5.2 lb. of water per pound of coal, and the efficiency was, roughly, 67 per cent. The other boiler, equipped with shaking grates, under like conditions, gave but 2.5 lb. of water per pound of coal, the efficiency being approximately 33⅓ per cent. The result was so much lower than that attained in the old plant, where plain grates were used and the boiler walls badly cracked, that the owners entered an emphatic protest.

Since the type of shaking grate was a good one, the stack capacity ample and the setting air-tight, it was conceded that the trouble lay in the extreme depth of the furnace. Luckily, the steel front was so sectionalized that the fire-door could be raised along with the grates so that the furnace depth would be made 26 in. instead of 54.

This was done and on a second test an evaporation of 4.45 lb. of water per pound of coal was obtained. This value is good for shaking grates using lignite that slacks badly and that causes an appreciable loss of fuel into the ashpit. Perhaps the cause was that the lignite gave a short flame and the great depth of the furnace allowed too much air to come in contact with the burning gases.

L. H. MORRISON.

Dallas, Tex.

[If the setting was air-tight above the grate the additional height of the furnace should have given good instead of poor furnace efficiency.—EDITOR.]

Diagonal Joints

The efficiency of a diagonal seam is a matter of angles and should be calculated for each different angle. J. E. Terman, March 2 issue, p. 296, compares the strength of a diagonal joint in a testing machine to a longitudinal joint of a cylinder. To take another view of it, let us compare the diagonal with a girth seam. That there is an additional strain in a diagonal joint in a boiler not exerted in a testing machine is pointed out by Mr. Terman. There is a generally accepted statement that the force tending to rupture a cylinder girthwise is one-half as great as that tending to rupture it longitudinally. This is equivalent to stating that the effective efficiency of a girth seam is twice as great as that of a longitudinal seam of like design. This can easily be shown mathematically, and the relation is so apparent that tests are not necessary to prove it. The relative strength of a diagonal seam compared to either a girth or longitudinal joint can be calculated, but under test conditions do not apparently come up to expectations.

As an illustration, consider a single-riveted diagonal seam to hold a patch. Suppose the single-riveted seam has an efficiency by test of 50 per cent. of the solid plate. It will then have an efficiency of 50 per cent. as a longitudinal seam and a comparative efficiency of 100 per cent. as a girth seam. A diagonal seam of the same proportion will have an effective efficiency somewhere between these two values, decreasing as it swings from the girth seam. If a section of the diagonal joint were tested it would probably fail at less than 50 per cent. The inclination is to jump at the conclusion that the diagonal seam is weaker than the longitudinal and that the calculations on the strength of diagonal joints are in error. A little further consideration of the matter shows that the test of the straight joint showed 50 per cent. and no more, yet with this joint in another position it will be, relatively, twice as strong.

If, then, we compare the strength of the diagonal seam to a girth seam instead of to a longitudinal seam, as has been the practice, we will approach nearer to the calculated efficiency for a diagonal joint. The test efficiency will show higher than calculated, and the error will increase as the diagonal joint deviates from the girth joint. This comes about because in the machine there is a pull in one direction, while in a diagonal boiler joint

there is an endwise and longitudinal pull combined, and until a testing machine is made that will pull in the two directions at right angles to each other, the result of tests along a diagonal line will not give very accurate results.

THOMAS GRIMES.

Houghs Neck, Mass.

In calculating the strength of a diagonal seam it is necessary to take into consideration the well known fact that internal pressure exerts twice the strain on the longitudinal seam or section of the sheet as on the girth seam or sheet section. In Fig. 1, *AB* represents a longitudinal seam, *CD* a circumferential seam, and *EF* a diagonal seam. Since the strain on a longitudinal seam *AB* is twice that on a girth seam *CD*, it is evident that

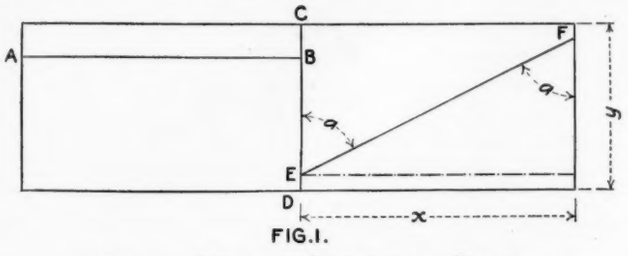


FIG. 1. RELATIVE POSITION OF SEAMS

the smaller the angle *a*, the greater the internal pressure a given diagonal seam will withstand.

Now, the force acting on a unit of length on a diagonal seam *EF* is the component of the girthwise and longitudinal stresses. In the three types of seams suggested, with the plate, size and pitch of rivets the same, the efficiency of the seams will be identical, but the internal pressure they will withstand will depend on the direction of the seam with reference to the axis of the cylinder.

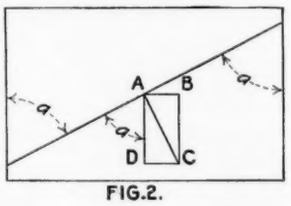


FIG. 2. CALCULATION OF EFFICIENCY OF DIAGONAL SEAM

P = the bursting pressure of the cylinder through the solid sheet and if *E* = the efficiency of the joint, the bursting pressure through the joint *AB*, Fig. 2, will be *PE*.

From this is derived the formula

$$AC = \frac{PE}{\frac{1}{2}P\sqrt{1 - 3\,sin^2 a}} = \frac{E}{\frac{1}{2}\sqrt{1 - 3\,sin^2 a}}$$

effective efficiency of diagonal seam, and from it a table of constants may be calculated.

The effective efficiency of the diagonal seam may be determined from the formula

$$EE = \frac{E}{\frac{1}{2}\sqrt{1 + 3\,sin^2 a}}$$

where

EE = Effective efficiency of diagonal seam;
E = Efficiency of joint calculated as a longitudinal seam;
a = Angle made by girth seam and diagonal seam.

With a table calculated from the formula, and by its use *E* and *a* being known, it is only necessary to divide *E* by the required factor to determine the effective efficiency of the diagonal seam; or, the efficiency of the longitudinal seam being known, to lay out a diagonal seam of equivalent efficiency at a given angle, multiply the efficiency of longitudinal seam by the factor corresponding to the given angle. The product will be the efficiency of the joint at that angle. In repair work we can calculate the efficiency of the longitudinal seam, assuming the highest efficiency *E* practical for the seam in the patch. Dividing the first into the second will give the greatest angle at which the effective efficiency will equal the longitudinal efficiency.

R. D. IRVINGTON.

Boston, Mass.

Piping Bubblers to Avoid Waste

Of all inefficient things, a bubbler drinking fountain seems the most wasteful. When, as boys, we used to lie down at the edge of a brook to drink, we did not think of the brook as flowing for that express purpose, but when we open a bubbler valve the flow is solely for the sake of getting a drink, and we consume about one per cent. of what flows and waste the rest.

We think of the installation of a drinking fountain as a plumber's job. A plumber will tell you at once that any waste pipe must go into the sewer. The water that has gone by one of these bubblers is just as good to feed the boilers, flush the closets, or for any mechanical purpose as it ever was.

The waste pipe can be made to discharge into an open tank or into the return tank of a vacuum heating system and thus improve the vacuum because the water is cold. There should be an effective check valve in the line so that hot water cannot back up into the bubbler. This is especially necessary if the drain pipe surrounds the feed pipe for a short distance. I know of a case where the water in the bowl which had backed up heated the supply pipe enough to scald a man by the first rush of water. It is better to discharge into a separate tank from which the water can be pumped wherever desired, and in that way prevent waste.

E. F. HENRY.

Worcester, Mass.

Vacuum Helps in Making Repairs

With high steam pressure and superheat there is likely to be more or less trouble when making repairs, on account of leaking stop valves on the sections of headers which have been cut out.

In some plants it is the practice to cross-connect the suctions of the dry-vacuum pumps. A convenient use can be made of this connection when making pipe repairs. If the section of the header cut out has a connection to an engine or turbine, the throttle can be opened wide, the inlet valves blocked open, the connection to the condenser opened, and the dry-vacuum pump will then draw the leaking steam past the point of repair.

Of course, the proper way would be to replace the valves, but this cannot always be done. However, with the bolts out of a flanged joint and the steam burning the hands, the foregoing stunt will be found worth while.

JOHN F. HURST.

Louisville, Ky.

Inquiries of General Interest

Crushing Strength of Boiler Plate—In computing the strength of a boiler joint what is understood by the crushing strength of the plate?

J. R.

The crushing strength of the plate is its ability to resist distortion from the compressive stress which is incident to drawing the sheet against one side of a rivet in exerting shearing stress in the rivet.

Safety of Cracked Mud Drum—Would it be safe to continue the use of a cracked mud drum of a water-tube boiler after drilling and plugging the ends of the cracks?

F. S.

The drilling and plugging might reduce the tendency of the cracks to extend in length, but could not otherwise increase the safety of the drum, which may not have sufficient strength for safety even if the cracks do not extend.

Relative Heat Value of CO_2 and of CO—What are the relative heat values derivable from carbon in fuel burned to CO_2 and to CO?

G. B.

When carbon is burned completely to CO_2 there will be given off 14,500 B.t.u. for every pound of carbon burned, but when CO is formed there are 4400 B.t.u. given off per pound of carbon burned, or less than one-third as much heat.

Relative Lengths of Pump Cylinders—Why is the water cylinder of a steam pump made longer than the steam cylinder?

J. W. D.

So that there may be latitude in length of the piston rod without the water piston overrunning or leaving too little clearance in the ends of the water cylinder for the greatest possible stroke of the steam piston in either direction.

Boiler Foaming from Temporary Use of Good Feed Water—How is it explained that the temporary use of a good quality of feed water causes a boiler to foam?

G. N.

Where a boiler is coated with scale a pure feed water will sometimes dissolve the scale, leaving the metal bare in spots which transfer heat much faster than parts that are covered with scale, and the violent boiling over places where there is little or no scale is likely to result in foaming or priming.

Circulating Pipe for Blowoff—How can a circulating pipe be connected to the blowoff pipe of a return-tubular boiler?

R. C.

A circulating pipe of a size smaller than that of the blowoff pipe can be connected from a point in the blowoff, outside of the rear wall and on the boiler side of the blowoff valve, to a point in the rear head of the boiler a short distance below the water line. The circulating pipe should be provided with a stop valve, which should be closed whenever the boiler is blown off, but at all other times should be left wide open.

Per Cent. of Fuel Saved by Heating Feed Water—What is the formula for calculating the per cent. of fuel saving from the use of a feed-water heater?

A. S.

For practical purposes the heat saved in raising the temperature of feed water may be regarded as directly in proportion to the rise in temperature. The steam pressure and feed-water temperatures before and after heating being known, the fuel saving can be computed by the formula,

$$\text{Fuel saving in per cent.} = \frac{100\,(t - t_1)}{H + 32 - t_1}$$

in which

t = Temperature F. of feed water after heating;
t_1 = Temperature F. of feed water before heating;
H = Total B.t.u. above 32 deg. F. per pound of steam at the boiler pressure (to be obtained from tables of properties of steam).

Maintaining Air Supply in Air Chamber—How can a supply of air be maintained in the pump air chamber of a high-pressure service pump?

J. G.

An automatic air pump for supplying the air chamber may be provided by connecting a vertical 2-in. or 2½-in. pipe about 30 in. long, with a stop valve at its lower end, to one head of the water cylinder and providing the upper end of the pipe with a tee and 1¼-in. check valve opening inward and a ¾-in. check valve opening outward and connected to the pump air chamber. For operation of the air pump it is necessary that the pump to which it is attached shall be in operation. To start the air pump, first open the valve connected with the water cylinder to charge the air pump with water; then partly close the valve until the check valves begin to work.

Compression of Steam in Duplex Pump—How is compression of exhaust accomplished in the steam end of a duplex pump?

W. L.

Separate steam and exhaust passages are provided in each end of each steam cylinder, the cylinder ports of the steam passages being located in the extreme ends of the cylinders or nearer the ends than the cylinder ports of the exhaust passages. The exhaust ports are placed so near together that before completing the stroke from one end of the cylinder the piston covers the exhaust port at the other end of the cylinder. When the exhaust passage is thus closed, any exhaust steam then remaining in the cylinder and steam passage on the exhaust side of the piston is compressed by it during the remainder of the stroke.

Computation of Indicator Diagrams—An 8x10-in. engine having a 2-in. diameter piston rod runs at 200 r.p.m. The indicator diagram from each end of the cylinder has an area of 2.5 sq.in. and a length of 4 in., and the scale of spring is 50 lb. per sq.in. What is the i.hp.?

S. H. E.

In each diagram the mean effective pressure would be $\frac{\text{area}}{\text{length}} \times \text{scale of spring}$, or $\frac{2.5}{4} \times 50 = 31.25$ lb. m.e.p. The area of the 8-in. diameter piston being 50.265 sq.in. and the cross-section area of the 2-in. diameter piston rod being 3.1416 sq.in., then for 10-in. stroke and 200 r.p.m., there would be

$$\frac{31.25 \times [50.265 + (50.265 - 3.1416)] \times \frac{10}{12} \times 200}{33{,}000} = 15.37 \text{ i.hp.}$$

Application of the Prismoidal Formula—What would be the cubical content of a piece of timber 16 ft. long, 6x6 in. at one end and 4x8 in. at the other?

T. E. H.

Assuming that the ends are parallel planes, as, for instance, both square with one of the edges of the timber, then the content can be found by the prismoidal formula

$$\text{Volume} = L \times \frac{A + a + 4M}{6}$$

in which

L = Length;
A = Area of one of the parallel ends;
a = Area of the other parallel end;
M = Area of cross-section midway and parallel to the parallel ends.

The ends being, respectively, 6x6 and 4x8, the parallel mid-section would be 5x7, and the length being 16 ft., then the volume would be

$$(16 \times 12) \times \frac{(6 \times 6) + (4 \times 8) + 4\,(5 \times 7)}{6} = 6656 \text{ cu.in.}$$

or

$$\frac{6656}{1728} = 3.85 \text{ cu.ft.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Future Methods of Utilizing Coal*

SYNOPSIS—Economic pressure due to increased demand and cost of coal will force improved methods of combustion and the recovery of the various byproducts contained. The relative costs of fuel and capital are the determining factors. There is no need for conservation as ordinarily understood. Future generations, with their fuller knowledge and wider vision, will be better able to take care of themselves.

There is at the present day a certain amount of coal buried in the earth's crust. Coal is being slowly formed at some points on the surface of the earth, but the rate of formation is so low in comparison with the rate of consumption that for all practical purposes the supply available for human consumption may be assumed to be that already formed. If this view is taken, it is evident that the amount of coal which can be used by man in the future is definitely limited; when he has used up the coal now in the earth's crust, or that part of it which he can extract, there will be no more available for use.

The estimates of the length of time which will elapse before this condition is attained vary greatly, but most of them allow humanity at least a few hundred years before the exhaustion of all available coal. Opinions as to what may happen when the time of ultimate exhaustion arrives are equally variable. Some believe that humanity must perish because of the enforced cessation of industries and because of the impossibility of keeping warm during the cold seasons of the year. Others believe that by that time hydro-electric development will have been carried to such a point that electrical energy will entirely take the place of heat derived from coal. Still others are satisfied to let the future take care of itself and to assume that the human brain is going to be able to continue to devise methods of changing the environment to suit the needs of the human animal.

I am inclined to take the last view myself, as I believe that the centuries of human history which are available show that each successive generation has become better able to force its dictates upon nature rather than to be subservient to the unrestricted action of natural forces. In other words, subsequent generations will be better able to care for themselves than the present generation and there is no need to waste good time and effort in trying to solve their problems for them with a smaller stock of knowledge and a narrower vision.

In taking this viewpoint it is not necessary to hold ourselves responsible to future generations for the use we make of the coal stores which we are depleting at such a rapid rate. We may consider ourselves free to use this material as our industrial development requires, though we are, in a certain sense, morally bound to make that usage as economical as possible on the basis of the general principle that it is not good economics to waste wealth of any sort.

If, then, we attempt to look into the future for the purpose of predicting the methods which will be in use for the utilization of coal, we must not warp our vision by an erroneous assumption of the necessity of conserving the supply. We must rather study industrial developments of the past and after discovering their general trend, attempt to apply this knowledge to the particular field under discussion.

It has been characteristic of nearly all industries that they started in a small way under conditions which did not require the most economical production. Thus the shoe industry was started by numerous individuals scattered over the country, who purchased leather, nails, thread and other raw materials in small quantities and then worked them up into shoes on individual orders received from people living in the immediate neighborhood. The modern packing industry sprang from the small butcher who slaughtered for local consumption and disposed of the hides and other byproducts in the easiest way possible. The clothing industry was originally confined to the home, the land or the live stock producing the raw material, which was worked up by the family of the owner into the clothing required by that family.

All of these industries have grown until they are scarcely recognizable as the offspring of their forebears. This has been brought about by organization, which is merely the combination of capital and the division of labor for the purpose of producing the biggest possible yield from given raw materials or natural supplies.

In the shoe industry scientific development produced the marvelous machines which are now used in producing leather and shoes and the railroads which later transport the factory-made product to the scattered consumers.

In the packing industry the refrigerator car made possible the concentration of the slaughtering industries and, coupled with mechanical and chemical invention, assisted in building up large modern plants.

Spinning and weaving machines, cutting, sewing and pressing machines, coupled with the railroads, have made possible the huge centralized clothing industries of the present day.

The study of the packing business tends to throw considerable light upon the probable future development of the coal industry. It is not so many years ago that, in this country at least, meat on the hoof was so plentiful that it could be slaughtered in most expensive ways and still be sold at a profit at such a low figure as to bring it within the reach of practically all families. Conditions are now different and meat on the hoof is comparatively scarce. It therefore brings comparatively high prices and if all or practically all of the purchase price, transportation and slaughtering expenses had to be borne by the meat and hide, the prices of these commodities would be so high as to put them beyond the reach of many families even in this comparatively opulent country.

But the modern packing house manages to sell every part of the animal for some purpose. Some parts, such as those sold in the form of dressed meat, are disposed of after little modification, while others, such as horns, hoofs and fat, pass through elaborate manufacturing processes before they are ready for the market. When it is remembered that every one of the numerous products is sold on the average at such a price as to bear its share of the cost of the animal, of its transportation, and its slaughter and dressing, it is evident that the principal product, meat, can be sold at a lower price than would otherwise be possible. Moreover, waste has been reduced to a minimum; all parts of the animal which cannot be used for food are used for other purposes.

The coal industry, particularly in this country, is in much the same position today as would be a packing house which produced meat only. Coal is removed from the mine, put in marketable condition with the minimum possible expenditure and shipped to the consumer. The greater part of it is burned under boilers just as it is received or after breaking to smaller sizes.

As the supply in sight in the ground decreases, as mines become deeper and as freight rates increase, coal becomes more and more expensive. This process must continue so long as the methods at present in vogue in the industry continue and the cost of coal must ultimately become a serious burden on industries in which the coal charge forms a large fraction of the total charge. In view of what has happened in other industries it is but natural to assume that when economic pressure makes it necessary, the coal industry or the methods of utilizing coal will be so modified as to obtain the maximum possible number of products with the maximum possible economic value from each ton mined, provided such products are obtainable.

We are accustomed to think of coal as merely so many stored or latent units of heat energy purchasable at so much per thousand or million. It is far better, however, to view it as a collection of chemical substances and combinations which are capable of almost an infinite number of transformations and recombinations to form innumerable new end products. If coal were merely a collection of units of heat energy the cost per unit would of necessity continue to increase until it reached a prohibitively high value. Taking the view just suggested, however, it is possible that chemical jugglery of the constituents may be made to develop substances marketable at such prices as to materially reduce the necessary selling price of units of heat energy.

The principal constituents of coal are carbon, hydrogen, oxygen, nitrogen and sulphur, and these are the blocks out of which innumerable organic and inorganic chemical compounds are built. Just how these various constituents will be liberated or recombined for the purpose of increasing the economic value of a ton of coal in order that the selling price of units of heat energy may be kept down to a reasonable figure, must be more or less a matter of speculation. It is, however, pertinent to note that processes of this kind are already in use in some of the European countries and particularly in Germany, and it is reasonable to suppose that

*Abstract of paper read by Prof. C. F. Hirshfeld befor the Detroit Engineering Society, Mar. 23, 1915.

future development will follow along some such lines as those already partially developed. An investigation of these methods may therefore assist in arriving at a more correct prediction of future methods.

In general, development is carried on along three lines: First, the thermal efficiency of heat engines and plants is brought to the highest possible figure in order to reduce to a minimum the number of heat units which must be purchased by anyone concerned in the generation of power; second, by-product fuels of various varieties are made from the raw coal, or from the coal in the process of utilization and some of these may have such desirable properties as to be worth more per unit of heat energy than is the raw product. Their use or sale therefore tends to reduce the price paid for heat units in the raw coal. Third, many byproducts useful in numerous arts are made and their economic value helps to reduce the cost at which units of heat energy or their products must be sold to yield a profit.

It will be observed that when the coal-mining and consuming industries develop in this way, they begin to approach the condition of the modern packing industry. The capital involved is enormously increased; many more kinds of labor are required and the subdivision of labor is carried to a far greater extent; and the economic value of the product per ton of raw coal is enormously increased.

The parallel may be drawn still more closely. Meat for human consumption may be considered the primary product of the packing industry. The selling price is continually increasing, but the rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product. Heat energy may be said to be the primary product of the coal industry and the selling price of this is continually increasing. The rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product.

Development along these lines has thus far progressed along two principal paths. The raw coal is subjected either to a destructive distillation process with the exclusion of air, or to a process of incomplete combustion in the presence of air. The former method yields a solid fuel called coke; combustible gases of a more or less permanent nature; condensible vapors of great chemical and fuel value; and other substances, such as ammonia, cyanides, sulphur compounds and others. The latter method yields solid, incombustible refuse or ash of comparatively small value; large quantities of combustible gas of great value; condensible vapors which are becoming of greater chemical importance daily and are also becoming available as fuel; and small quantities of chemical compounds of more or less value.

By such means as these fuel material becomes available in solid, liquid and gaseous forms, and the particular variety best suited to any use may be chosen therefor if price permits. It is, of course, impossible to obtain more heat units than were originally contained in the fuel. There is in reality always a loss in these processes, but the thermal efficiency with which the smaller number of resulting heat units can be used may more than balance the thermal losses occurring during the modification of the fuel. Great developments have been made in the use of gaseous and liquid fuels during the past few years. It is now possible to use such fuels for the generation of steam, for industrial heating, and for the operation of prime movers at efficiencies much higher than seemed possible of attainment a short time ago. Surface combustion and the internal-combustion engine in its various forms are pointing out lines of development leading toward constantly increasing thermal efficiencies.

These statements must not be interpreted as an argument for the immediate adoption of gas firing and of the universal use of the internal-combustion engine. Other matters must be given consideration as well as the cost of fuel. The cost of capital is of equal importance.

At present the costs of capital and of fuel are both increasing, but the cost of the latter is increasing more rapidly than that of money. Even now the cost is such as to warrant greater capital investment for procuring greater thermal efficiency than could have been justified a few decades ago. Ultimately the cost of fuel must rise to such values as to warrant the investment of the necessary capital and the training of the necessary labor to make possible the use of fuel in such ways as to produce the greatest economic production per ton of raw material.

When that time comes it is probable that coke, or something resembling it, will be the principal solid fuel; gases formed during the production of the solid will be used in internal-combustion engines, or by surface combustion, or in ways not yet discovered; and liquid fuels formed during the production of solid fuel will be used in high-efficiency, liquid-fuel engines. Before they are used the liquid and gaseous fuels will be robbed of many valuable constituents, which will be used in producing fertilizers, medicines, paints, dyes, preservatives, waxes, flavoring extracts, commercial chemicals and many other products yet undreamed of.

Summarizing these ideas, it seems probable that:

1. Improved or more economical methods of utilizing coal will not and need not be brought about by any consideration of conservation as ordinarily understood.

2. Such methods will be brought about by cumulative economic pressure due to the natural operation of increased demand for fuel combined with decreased quantities and increased cost of mining and transportation.

3. When such methods are thus forced upon humanity they will follow, in a general way, the course developed in other industries under the force of similar circumstances.

4. These methods will consist of a preliminary treatment of the raw material to produce fuels with different physical and chemical characteristics which will adapt each form to use in particular kinds of apparatus or in particular industries.

5. Coincident with this treatment will be produced numerous non-fuel byproducts of great value in the then existing markets.

6. The spreading of the cost of the raw material over so many products will prevent the excessively rapid rise in the selling price of fuel per heat unit and this, combined with high efficiency methods of utilization made possible by the relative prices of fuel and capital, will yield the same sort of an economic balance as now exists. Humanity will probably then, as now, bemoan the fact that it could not have lived several generations before, when fuel was "cheap," and will probably express great sympathy for the coming generations that will have to face the problems of life with a still more depleted coal supply.

Many will probably object that the cost of modifying coal, as, for instance, by the destructive distillation process, has always been so expensive that little is to be hoped for along such lines in the future. In answer to such criticisms it is only necessary to point out the fact that despite the rising prices of coal, labor and capital, the selling price of gas made by such processes has steadily decreased. It is admitted that further decrease cannot be brought about by exactly the same methods as have been used in the past, but it shows very little faith in the progress of the human race to assume that the present status in any industry represents the ultimate development of which humanity is to prove capable.

Refrigeration Night, Chicago Section, A. S. M. E.

The chief paper presented before the meeting in the Grand Ball Room of the LaSalle Hotel, Mar. 19, was by Heywood Cochrane, Western manager for the Carbondale Machine Co. The subject was "Ice Making as a Byproduct for Central Stations," a digest of which follows:

One point of difference between the electric-light and the ice plant is that of distribution. There is hardly any limit to the extent of the former, but the latter soon reaches a size where the cost of distribution more than offsets the saving. Individual plants of from 80 to 150 tons, located in the best centers of distribution, are preferable to large-capacity plants adjacent to the station.

With condensing water under 70 deg. F. it is possible to use exhaust steam at 3 lb. pressure in the generator of an absorption system. This steam is condensed, furnishing a portion of the distilled water required for making ice. About 55 to 60 lb. of steam per hour per ton of ice is required for this purpose. With condensing water at 90 to 95 deg. it is not possible to run on less than from 20 to 25 lb. exhaust-steam pressure, because of the high condensing pressures necessary. Such pressure would seem prohibitive, yet plants operating under these conditions are proving economical. It is not generally known that, properly designed, the absorption machine is an ideal installation for warm water conditions. Just as it takes little more coal to carry 125 lb. boiler pressure than it does 100 lb. (less than 1 per cent.), it takes comparatively little more steam in the generator to produce an ammonia pressure of 200 lb. than it does 150 lb.

An electrically driven compression plant will require from 43 to 70 kw.-hr. per ton of ice, depending upon its size and local conditions. At 1c. per kw.-hr. the power costs per ton will usually average between 50 and 60c. From the central-station manager's standpoint, in the larger cities, such as Chicago, the privately owned electrically driven plant is the

proper combination, while in smaller cities it is much more profitable to own the ice plant direct.

It is possible in a properly designed compression and absorption plant, say of 80 tons' capacity, with a 20-ton machine of the former type and a 60-ton of the latter, to make ice at a lower fuel cost than 35c. In this case there should be two 40-ton tanks, the compression machine being used on one-half the coils of one tank and the absorption machine on the rest. The steam from the compressor and auxiliaries would furnish the 3600 lb. of exhaust required for the generator of the absorption machine. Making all raw-water ice with coal at $2 per ton, having an evaporative efficiency of only 6 to 1, 6½ tons would be required and the fuel cost would be 16c. per ton of ice. Such an 80-ton plant could be run on a 125-hp. boiler, and with a second such boiler in reserve, the first cost, interest, depreciation, etc., would be low, so that including labor it should hardly be more than 30c. per ton.

If a neighbor could be found requiring a certain amount of power and heat, a straight 80-ton absorption machine could be installed. By using the expansive force of the 4800 lb. of steam per hour required by the generator, in an economical uniflow engine, current could be sold, not bought, which would further reduce the operating cost.

One drawback about the electrically driven plant is the possibility that public-service commissions at any time may decide that the rates quoted ice plants are too low and order them raised. Rates higher than 1c. per kw.-hr. seem prohibitive, although they are paid in some places. Sometimes the ice-plant manager looks only at the comparatively low operating cost when running full capacity and forgets that service charges add to the cost at other times. The importances of such charges should never be underestimated.

A properly designed combination plant owned by a central station in a Southern city of about 50,000 inhabitants was described.

REFRIGERATION VS. HEATING

Otto Luhr was asked to explain in an elementary way the principles of operation of a refrigerating system. He did this by comparing it to an ordinary steam-heating system, as in reality it is nothing more than a heating system reversed, with the only difference that in a steam-heating system heat is carried into the rooms that are to be heated, whereas in a refrigerating system heat is carried out of the rooms that are to be cooled. In both cases the latent heat capacity of the heat-carrying mediums is of vital importance. In ordinary steam-heating systems there is a boiler and heating coils. The boiler is partly filled with water, and the heat that is created by the combustion of fuel is absorbed by the water, which is changed into steam by the constant addition of heat. This steam is conveyed to the heating coils at comparatively low pressure and temperature, the latter usually being about 212 deg. F. As the room temperature is generally about 70 deg. there is a difference of 142 deg., and heat will constantly flow from the radiators into the surrounding air.

With the refrigerating system the reverse process takes place. The system consists of a heat-carrying medium confined in piping similar to that of the heating system. If the medium could be purchased cheaply no further apparatus would be necessary, but as it is expensive the heat absorbed by it must be abstracted and used over and over just as is the water in a heating system. To do this a heat elevator in the form of an ice machine and a heat extractor in the form of a condenser become necessary. The temperature of the medium is raised either directly by steam or by the application of power in the form of compression. It is necessary to raise the temperature of the medium in either of these two ways so that water or air of ordinary temperature will remove some of the heat contained. Water is generally used, as it is cheaper. It has the same effect on the heat-carrying medium as the room temperature has on the heating system. When it arrives at the condenser the medium is in a gasified state, and by the action of the cooling water, which constantly takes heat away from the gas, it is liquefied. It is then ready to start on the same cycle, which is constantly repeated.

Mr. Luhr explained how the liquid ammonia in the coils was vaporized by absorbing heat from the room to be cooled, and enumerated some of the qualifications which go to make up a good refrigerating medium.

As to the different systems, each was well adapted for specific cases. For instance, it is not good policy to use a CO_2 machine when the cooling water is scarce or high in temperature. On the other hand an ammonia-compression machine would not be desirable when there was plenty of exhaust steam and an abundance of low-temperature cooling water, especially when low temperatures were to be carried in the cooling system.

The principles of operation of refrigeration systems can best be understood by keeping a steam engine or a heating system in mind and considering the refrigerating end a reverse process. In a steam engine the efficiency is the greatest the farther apart the inlet and outlet temperatures of the steam. In the compressor it is just the reverse; that is, the closer the two temperatures can be brought together the higher will be the efficiency. For this reason it is necessary to work with a suction pressure as high as possible and with a condenser or discharge pressure as low as possible, as long as the proper refrigerating results can be obtained. This means that the pipe surface in the refrigerating room must be large, so that the difference in temperature of the medium in the pipe and the air surrounding the pipe can be small.

CO_2 MACHINES

Fred Wittenmeier, vice-president and chief engineer of Kroeschell Brothers Ice Machine Co., explained the action of the CO_2 machine, which is now made in capacities up to 150 tons. Its greatest application is in hotel basements, on board ship and in other places where space is limited and where the escaping fumes from a possible rupture of the pipe lines might cause serious inconvenience.

In the last ten years air cooling by means of the CO_2 system has also made rapid progress. The usual practice is to place direct-expansion coils in the air washer. The properties of CO_2 were briefly given, and the results of tests made on an air-cooling system in a church and on an ordinary refrigerating system on board ship were shown on the screen. The principal object was to show that with condenser water in the eighties good results could be obtained from the CO_2 system, notwithstanding the general belief that it is not adapted for use with high-temperature cooling water. In the test on the air-cooling system, the water went into the condenser at 84 deg. and came out at 106 deg. From the ship log the inlet temperature of the water was 82 deg. and the outlet temperature 88 deg. As far as economy was concerned, under normal conditions the CO_2 system gave results comparable to those obtained from ammonia or SO_2 systems.

FROM THE VIEWPOINT OF THE CENTRAL STATION

E. W. Loyd, of the Commonwealth Edison Co., discussed the topic of the evening from the viewpoint of the central station. In efforts to obtain a load which would improve their load factor, particularly in the summer months, an investigation was made of the ice-making field. Many data were collected and the amount of power required for refrigerating installations determined. This was turned into kilowatt-hours and a price fixed at which the company could sell current. Rapid progress has been made and one third of a million tons of ice is now produced in the City of Chicago by central-station power. This is 10 per cent. of the total made in Chicago, and has been made possible by the recent developments in raw-water ice making. The trend seems to be toward raw-water ice where fairly pure water can be obtained. It was originally estimated that the load factor on an ice plant was about 65 per cent., but according to data collected by the company the annual load factor does not exceed 45 per cent. Exceptions were found, but in any case it was not above 65 per cent. on an annual basis. As to the kilowatt-hours required per ton, there was a wide variation, largely due to the varying efficiencies of the plant and the equipment installed. The company found that the number of cans employed per ton of ice has a bearing on the subject. At the present time they were supplying 7000 hp. for ice making, and the total amount of power required for this purpose in the city was estimated at 70,000 hp. The rate charged was 1c. per kw.-hr. An analysis shows that the distributing cost is low, as the current is delivered in large quantities to one service. The increment of cost to take on this business was a minimum. It increased the summer load and reduced the overhead charges, and it could be shown that the rates were comparable to those for other classes of service.

MULTIPLE-EFFECT COMPRESSION

By means of some simple experiments and lantern slides Gardner T. Voorhees explained the action of his device designed to obtain multiple-effect compression. Low-compression vapor first enters the cylinder, and near the end of the stroke vapor under a higher pressure is admitted. The cylinder thus contains a denser charge and at the same speed does more work, or the same amount of work with less power. The device by which these results were obtained was illustrated and the results of a number of tests given to show the economies obtained. In one particular case, with 90 deg. F. cooling water, 70 per cent. more ice was made for 25 per cent. less power, after the compressor was fitted for multiple-effect compression. Slides of the Quincy Market Cold-Storage

& Warehouse Co.'s (Boston) machine, the largest in the country, were shown. This machine, designed by F. L. Fairbanks, is fitted with a multiple-effect compression device and has given excellent results. For a complete description of this machine see "Power," Dec. 8, 15, 22, 29, 1914, and Jan. 6, 1915.

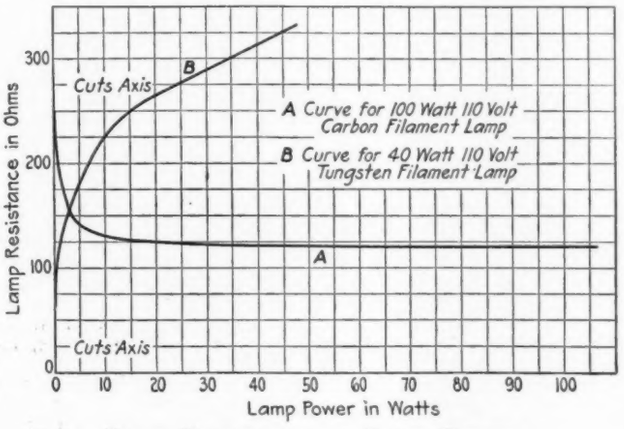
Dimmers for Tungsten Lamps*

By A. E. Waller

The introduction of tungsten lamps has brought about a complete redesign of the apparatus used for lamp dimming in theatrical work. The control rheostats, or dimmers, which were built to regulate the illumination of carbon lamps were found unsatisfactory when the carbons were replaced by the metallic-filament tungsten lamps.

The resistance characteristics of the two types of lamps in actual operating conditions indicate the reason for the difficulty. Tungsten has a positive temperature coefficient of resistance, while carbon has a negative temperature coefficient. For instance, if we have a carbon and a tungsten filament of the same cold resistance, when both are at full incandescence, the tungsten will have 35 times the resistance of the carbon filament.

The curves shown were plotted from tests made on a 40-watt tungsten lamp and on a 100-watt carbon lamp, both giving practically the same candlepower at 110 volts. Curve A, which is for the carbon lamp, has little slope between the 10- and the 100-watt abscissas, an interval which represents the working range of the lamp. Since the lamps must be totally extinguished without opening the circuit,



Lamp Resistance vs. Lamp Power

the dimmer is built with enough resistance to reduce the input below 10 watts, in this case to 6 watts, which is attained at 28 volts.

The calculation of the resistance per step of a dimmer for a carbon lamp is similar to that of a generator field rheostat, or of any other controller operating in series with a substantially constant resistance across a constant-supply voltage. The current of the lamp at the rated 110 volts is 0.9 amp., the minimum to which this will be reduced by the rheostat is 0.18 amp., and the working resistance of the lamp is approximately 122 ohms. At the minimum current the resistance is actually 138 ohms, but it is satisfactory in designing to take the resistance as constant at 122 ohms.

The negative coefficient of the carbon filament produces a slight change of resistance which assists the action of the dimmer. When a resistance step is cut into circuit, the current flowing is reduced, the filament cools and increases in resistance, which causes a further slight decrease in the current. Any part of the rheostat cut out of circuit increases the current, thus raising the filament temperature and allowing a slightly greater current to pass. This action is most pronounced at low voltages, the lamp resistance remaining practically constant over the greater part of the working voltage.

In striking contrast is the tungsten lamp, which opposes every attempt at control, and must be regulated by much finer divisions of resistance to get gradual dimming. The shape of curve B indicates that the tungsten filament changes in resistance throughout the entire working range of the lamp; furthermore, that the rate of change is not constant. The correct resistance for each step is readily obtained by calculating the resistance required in series with the lamp at various voltages. At 110 volts the tungsten lamp takes 0.35 amp., and the minimum is 0.08 amp. at 10 volts. The corresponding resistance change is from 312 to 125 ohms.

A comparison of curves A and B shows the marked contrast between the tungsten and the carbon lamps. The resistance of the tungsten lamp at full incandescence is about 16.5 times its cold resistance, while that of the carbon filament at full incandescence is approximately half the cold resistance. The tungsten filament becomes visible red at 10 volts, the carbon at 28 volts.

*From a paper presented at the midwinter convention of the American Institute of Electrical Engineers, New York, Feb. 17 to 19.

Two Flywheels Explode at Illinois Steel Co.'s Plant

During the morning of Mar. 17, shortly after 3 o'clock, two immense flywheels exploded in the No. 1 rail mill of the Illinois Steel Co. at South Chicago. Out of 150 employees imperiled, one man was killed, two have since died, two more were scalded about the face and arms by escaping steam and a fifth received two scalp wounds. The property damage is estimated at $75,000, and about 300 employees will be thrown out of work until the mill can be rebuilt, which will probably take about six weeks. That more were not killed or injured is a marvel that might be explained by the immediate rush for safety by employees accustomed to danger and consequently alert to the slightest warning.

After a shutdown for the winter, the mill had been reopened about 10 days previous to the accident. It consists of a long building about 80 ft. wide, housing three compound engines and their respective rolls. The dummy engine, which caused the accident, was located at the north end of the mill, the finishing engine 112 ft. south, and 104 ft. farther on the blooming engine. They are all of the tandem-compound type and practically in line. The dummy engine was installed in 1890 and compounded in 1905. It had cylinders 34&60x66 in. and a speed of 80 r.p.m. The flywheel, which was of the solid-rim split type, weighed 65 tons, and its dimensions were about as follows: Diameter, 25 ft.; face, 20 in.; thickness of rim, 20 in. The finishing engine had cylinders 40&70x66 in. and a 70-ton flywheel. The blooming engine was about the same size.

From the blooming rolls the bars of metal are passed along to the roughing rolls driven by the finishing engine, then to the dummy rolls and back to the finishing rolls. At the time of the accident a bar had just been rolled by the dummy engine and passed back to the finishing set of rolls at the center of the mill. While waiting for another bar to be delivered from the roughing rolls, the dummy engine speeded up and the flywheel exploded. The flying pieces from this wheel caused the flywheel on the finishing engine to give way, and between the two 125 ft. of the roof was brought to the floor. A traveling crane having a 77-ft. span, and at the time being located above the dummy engine, was demolished, but in stopping some of the heavy parts helped to save a considerable portion of the roof. Of the few pieces landing outside the building, one passed down into a shed and damaged a number of motor armatures which had been stored there.

The low-pressure cylinder of the dummy engine was demolished, the connecting-rod broken and the bedplate cracked at the bearing. The finishing engine was stripped of its valve gear. A piece of one of the flywheels smashed a valve bonnet on the high-pressure cylinder of the blooming engine and ruptured the steam connection between the two cylinders. A wiper on this engine was instantly killed and a machinist and a helper burned about the face and arms by the escaping steam. More damage at this point was prevented by a roll rack containing nine 30-in. rolls, three high and three wide. Seven were broken. The engineer on the finishing engine was so badly hurt that he died a little later, but the engineer of the dummy engine escaped with a couple of scalp wounds.

Fortunately, the steam piping had been designed for just such a contingency. The main supply pipe had been carried outside the building. The pipe leading to each engine passed through the wall, then down and directly across to the throttle, so that there was no overhead piping to flood the mill with steam in case of a rupture.

The governors were of the standard automatic-cutoff flyball type, driven from a sheave on the main shaft by three independent ropes. In addition, each engine was equipped with a quick stop which might be operated from a number of push buttons placed in convenient locations. There was no automatic stop to set a definite limit on the speed. Such

a device in working order, whether electrical or mechanical, would have prevented the accident.

Several years ago an automatic electric stop had been tried out on the blooming and finishing engines, but the graphite, scale and dirt common to steel mills interfered with its operation. The contacts would build up, close the circuit prematurely and frequently stop the engine with a bar in the rolls. It was not stated how often the contacts were inspected, but the result was a discontinuance of the automatic feature. Dependence was placed on the engineer at the throttle and the hand-operated stops previously mentioned.

In his report the engineer of the dummy engine claimed to have pushed one of the buttons, but apparently too late to save his engine. This action, however, would shut off the steam and eliminate one of the sources of danger.

Admission to the scene of the explosion was not granted, so that it is impossible to form accurate conclusions as to the cause of the accident. It was claimed that all the equipment was in good order, as far as known. No flaws were detected in the metal of the flywheels, and the governors had operated satisfactorily during the 10 days since the shutdown.

The following theories are advanced as possibilities: Not infrequently, water finds its way into the pits of the flywheels. Some of it may have been splashed on the ropes driving the governor, causing them to slip and allowing the engine to run away. Breakage of the ropes would produce the same result. Either might happen in the grease- and scale-laden atmosphere of a steel mill, depending upon the frequency and thoroughness of inspection.

Water-Power Motor Drive in a Flour Mill

An extremely flexible arrangement has been worked out by the Northwestern Consolidated Milling Company for one of its large flour mills at Minneapolis. This plant is driven by both a waterwheel set and a large synchronous motor connected to the same shaft. When water is plentiful the turbine wheel is operated at full load, pulling the mill and converting its surplus power into electrical energy in the motor unit, which is for the time operated as an alternating-current generator. The electrical energy thus generated, amounting to several hundred horsepower, is used to supply other mills and elevators operated by the same company.

When, however, the output of the waterwheel is insufficient to pull the mill itself, the synchronous motor is called into service, taking its supply from the mill steam-turbine plant. In case of low water this motor is used to drive the whole mill. On still other occasions, when the mill is shut down and it is desired to utilize the water power, the waterwheel can again be used to drive the motor unit as a generator, feeding its entire output into the mill system. In preparing the switchboard connections for this flexible arrangement it was, of course, necessary to provide for reversing the wattmeter connections by means of a reversing switch when the motor is operating as a generator.—"Electrical World."

Turbines in Warships

Once more the U. S. Dreadnaught "North Dakota" is in drydock for repairs to her turbines. These engines have been in trouble a good part of the time since the big ship was launched in 1910, and the navy's experience in this case has been such an unhappy one that it is unlikely that engines of this kind will be installed in new battleships.

Something like $200,000 has been spent on the "North Dakota" for repairs in five years, nearly half of which has been for repairs to the turbines. Naval experts deny that the frequent troubles with the engines are due to defects in material or construction, but charge the cost wholly to inaptitude.

Curtis turbines were installed in the "North Dakota" as a test for this type of engine and the "Delaware," a sister ship finished and launched in the same year, was equipped with reciprocating engines. On their trial trips the "North Dakota" made her required speed of 21 knots an hour, while the "Delaware" did half a mile better. Navy Department officials say that in coal consumption and efficiency the turbines have not made good, in comparison with other types of engines. At cruising speed, the coal consumption of the "North Dakota" has been from 30 to 40 per cent. greater than that of the "Delaware," even when the turbines were working well and in good repair.

Most of the trouble with the "North Dakota's" engines has been with her blading, and most of the repairs have been in renewing defective blading, nozzles, and the like. When she was sent to the Norfolk yard last month, to again undergo repairs, an examination disclosed that most of the blading in the first and second rows of the first stage were broken, having been bent over and twisted out of shape by the steam pressure, almost like so much cardboard. It is now being repaired, and when finished, the ship will again be placed in commission, although it is the opinion of the department steam engineers that eventually the turbines will have to be removed and replaced with either electrically driven machinery or turbine reduction gear.

OBITUARY

W. C. GREEN

W. C. Green, well known to the Western mining trade for the past 25 years, and for the past six years representative of the Mechanical Goods Department of the Diamond Rubber Co., died Feb. 13, from an attack of pneumonia. Mr. Green's work for the Diamond Rubber Co. will be carried on by C. A. Tracy.

FREDERICK W. TAYLOR

Frederick Winslow Taylor, distinguished for his labors in the field of increasing industrial efficiency, and the originator of the Taylor system of scientific management, died in Philadelphia, Mar. 21, of a sudden attack of pneumonia.

He was born in Germantown, Penn., in 1856, and received his early schooling in this country and in France and Germany. Impaired eyesight prevented his entering college at the age of 18, and he began an apprenticeship in a Philadelphia pump works. Completing this course, he entered the Midvale Steel Works and shortly afterward was in charge of the toolroom. In six years he was chief engineer of the company. By night study he was enabled to obtain an engineering degree from Stevens Institute in 1883.

While at Midvale he studied systematically the production and its expense, and increased the output 200 to 300 per cent. by increasing the men's pay 25 to 100 per cent. Later, this became his specialty: "The development and application of the science of shop organization and management." From 1890 on he practiced as a consulting engineer along these lines. In 1898, while retained by the Bethlehem Steel Co. to increase its machine-shop output, he with Maunsel White discovered the Taylor-White process of heat treatment, increasing the cutting efficiency of tool steel.

He presented two notable papers to the American Society of Mechanical Engineers: "A Piece-Rate System and Shop Management" and "The Art of Cutting Metals." In 1906 he was president of the society.

PERSONALS

W. D. Ranney has been appointed chief smoke inspector for the City of Columbus, Ohio.

William Siebenmorgan, formerly chief engineer of the C & C Electric & Manufacturing Co., of Garwood, N. J., is no longer connected with that company, his resignation having taken effect early in February.

ENGINEERING AFFAIRS

The American Society of Mechanical Engineers is to hold a meeting in San Francisco on Sept. 16 and 17, in connection with the Panama-Pacific Exposition. For the benefit of those who will attend, a special train schedule will be arranged over the Southern Pacific. It is planned to pick up at New Orleans those members who will start from the Middle West or South and other points farther west than New York. According to the schedule as at present arranged, the party will leave New York either Thursday evening, Sept. 9, or Friday evening, Sept. 10, and will stop at Niagara Falls, the Grand Cañon and possibly Colorado Springs. The Hotel Clift has been selected as the headquarters of the society during the meeting. An International Engineering Congress will be held in San Francisco from Sept. 20 to 25.